

THE  
PLEASING PRECEPTOR;  
OR *W. Mitchell*  
FAMILIAR INSTRUCTIONS  
IN  
NATURAL HISTORY AND PHYSICS,  
ADAPTED TO THE  
CAPACITIES OF YOUTH,  
AND CALCULATED EQUALLY TO INFORM AND AMUSE  
THEIR MINDS DURING THE INTERVALS OF  
MORE DRY AND SEVERE STUDY:  
TAKEN CHIEFLY FROM THE GERMAN  
OF  
GERHARD ULRICH ANTHONY VIETH, *K*  
MATHEMATICAL TEACHER AT DESSAU;  
INTENDED FOR  
THE USE OF SCHOOLS,  
AND  
ILLUSTRATED WITH CUTS.

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VOL. I.

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Simul et jucunda et idonea dicere vitæ.

HORAT. DE ARTE POET.

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LONDON:

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1800.

THE PRINCIPLES OF  
NATURAL HISTORY AND ZOOLOGY

ADAPTED TO THE  
CAPACITIES OF YOUTH

AND CALCULATED TO IMPART TO THEM  
THE KNOWLEDGE OF THE NATURE OF THE  
MINERAL, VEGETABLE, AND ANIMAL KINGDOMS

TAKEN CHIEFLY FROM THE GERMAN  
OF



THE USE OF  
SCHOOLS

ILLUSTRATED BY  
J. G. COOPER

VOL. I.

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1871.

LONDON:



PREFACE.

OF all the studies, in which the minds of youth may be employed, none, perhaps, deserve more strongly to be recommended, than those of natural history and physics. The objects on which they are occupied being such as come under the cognizance of our senses, they are more easily comprehended by the juvenile understanding, than the refinements of grammar, or the abstract ideas of moral philosophy: at the same time they afford an inex-

haustible fund of entertainment ; and their great utility to all, whatever may be their future destination in life, no one will dispute.

Still this is not the whole of their recommendation. They tend in a super-eminent degree, to expand and enlarge the mind, and inspire it with the most exalted notions of that ineffable First Cause, from whom all things in nature received their being, and by whom the laws, that regulate and uphold them, were ordained. Neither are they by any means unconnected with moral philosophy ; for, to the most valuable part of morality, practical morals, they frequently lead.

Every attempt, therefore, to diffuse a knowledge of these kindred sciences,

and facilitate their acquisition, may reasonably hope to be received with candour; and, if tolerably executed, may be presumed not to have been offered to the public in vain. That these sciences may be studied systematically with advantage, is not disputed: but, this is in the power of few; and many a youth, whose time and opportunities are unequal to such an undertaking, may acquire a considerable portion of much useful knowledge, in a less laborious and more agreeable manner, by having his attention turned to objects about him, and being made acquainted with the nature and physical principles of such, as may reasonably be supposed to come in his way.

Such has been the opinion of many judicious men; and Mr. Vieth has at-

tempted to carry it into execution, as it appears to me, with considerable skill. Much of the instruction he gives, much of the knowledge he conveys, will be found extremely entertaining; and the whole is divested as far as possible of that dry form, from which the teaching of a science systematically is inseparable. "To explain objects," I use his own words, "that occur in nature and in common life, which are adapted to the comprehension of young persons, in a perspicuous manner, and so as to render them palpable to the senses, was the basis of my design. This I have endeavoured to accomplish in short detached pieces, under the form of dialogues, narrative, or letters; and, for the sake of giving variety to the entertainment, I have not confined myself to any systematic order. Hence I shall



appear occasionally to have touched upon subjects before their natural course; yet the intelligent reader will easily perceive, that this has not been done at adventure."

To this I must add, however, that it is the plan of Mr. Vieth, to publish a similar volume every half year, till something very like a complete system of physical science is produced; so that a general knowledge of nature may be acquired from the work by almost imperceptible degrees, in a pleasing manner, and without any arduous toil. In giving his work an english dress, I have stripped it as much as possible of it's foreign garb; and, instead of a slavish adherence to the original, I have added, retrenched, or altered, as appeared to me necessary, to render it more com-

pletely suitable to the use of english schools, and the instruction of english youth. Manners and customs vary; though nature and nature's laws are every where the same.

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4. The fourth part is devoted to a description of the various species of the genus *Urocyon*.
5. The fifth part is devoted to a description of the various species of the genus *Procyon*.
6. The sixth part is devoted to a description of the various species of the genus *Nyctereutes*.
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THE  
PLEASING PRECEPTOR;

OR,  
FAMILIAR INSTRUCTIONS, &c.

CHAP. I.

SWIMMING IRON.

"DO you think I can make iron swim?"  
said William to his sister Caroline.

Caroline. "No."

William. "Indeed I can."

C. "I dare not suppose you capable of  
asserting an untruth; yet I must doubt the  
fact, till I see it with my own eyes."

W. "Lend me a needle."

C. "What, you mean to stick it into a  
cork, and call that making iron swim?"

W. "No, indeed: I will lay it fairly and  
by itself on the water."

Caroline took a needle, and put it into a  
glass of water. It immediately sunk to the

bottom. "Pray now let me see you do it."

William filled the glass brimful of water; took a fine needle, which he held carefully endwise between the points of his forefinger and thumb, and laid it very gently on the water, so that its whole length touched the surface at once.

*W.* "See there, Caroline: I told you I could make iron swim: I can make silver swim too?"

William took a very thin silver coin, laid it flat on the surface of the water, in the same cautious manner as he had done the needle, and it swam likewise.

*C.* "How is it this happens? Iron and silver are both heavier than water, and I thought nothing would swim, unless it was lighter."

*W.* "I do not know the reason of it. I only learned the trick from one of my school-fellows."

*C.* "We will ask our father: I dare say he can tell us."

William and Caroline went to their father.

*C.* "Father, William has just been mak-



ing a needle and a piece of money swim upon water : why was it they did not sink ?”

*Father.* “ You are right, Caroline, not to satisfy yourself with the performance of the trick, without inquiring into the principles of it. You should always do this, my dear children. On every occasion examine into the grounds of things : every effect must have a cause ; and though sometimes we may not be able to discover the cause, we shall benefit something by the very habit of reflection itself. To him, who does not reflect on what he sees, a thousand natural occurrences appear miraculous. Many feel no inclination to reflect on phenomena such as this and several others, and hence arises baneful superstition.—But to William’s tricks.—The needle and the coin do not properly swim ; they are rather sustained on the water.”

*C.* “ What am I to understand by that ?”

*F.* “ The particles of water have an evident cohesion together, though but a slight one. Now if any body, though heavier than an equal bulk of water, be not heavy enough to overcome the cohesion of all the particles that support it, it will swim ; though, if this cohesion be once broken, it will sink to the

4 THE PLEASING PRECEPTOR.

bottom. Look attentively at the water, where the needle lies upon it, and tell me what you observe."

*W.* "The surface of the water is regularly depressed by the needle, and forms a sort of rim round it."

*C.* "I understand now why my attempt did not succeed. I did not lay the needle lightly upon the water, and all it's parts at once."

*F.* "You are right: the cohesion of the water in the point where the needle first touched it was instantly overcome by the weight of the needle, and so it was in all the other points in succession; but if the cohesion of it in all these points had been to be overcome at once, the resistance would have been greater than the pressure of the weight of the needle, so that it would have been sustained on the surface. You may observe the cohesion of water in every drop that hangs on the eaves of the house: it remains suspended, till by the addition of fresh particles of water it acquires sufficient weight, to overcome the cohesion where it is drawn out into a neck, when it falls to the ground."

## CHAP. II.

## WATER THAT DOES NOT WET.

"I will now show you another experiment," said Mr. Goodwyn, dropping a halfpenny into a glass of water. "Can either of you take this halfpenny out with your bare fingers, without wetting them?"

Neither William nor Caroline knew how it was to be accomplished.

F. "See, I will throw a little of this yellow powder\* on the water, and when the surface is covered with it, you may dip your fingers into the water without wetting them."

Caroline put her fingers slowly into the glass, felt the cold water round them, and was not a little surprised, when she took them out with the halfpenny, to find them dry.

F. "You want to know the reason of this, do you not?"

C. "I own, I do not understand it."

W. "I, too, should like to know why it is so."

F. "I will tell you. When we say a thing dipped into water is wetted, it im-

\* The seed of the common clubmoss, *Lycopodium clavatum*, Lin.

plies, that the particles of water adhere to it. Now there are many bodies, to which water readily adheres, and this with more force than the particles of the water cohere together. Such a body, when it is taken out of the water, brings out particles of the water adhering to it; as a piece of paper does, or the fingers, for example. On the contrary, there are other bodies, to which the particles of water adhere less forcibly, than they cohere together; and as such bodies, when taken out of the water, cannot bring out any particles of water with them, they remain dry. Such, for instance, is a tallow-candle, or any thing of a greasy nature in general, as well as this powder, with which I have just made the experiment. This powder forms a kind of film over the water, and adheres to the finger like a glove; consequently, as the particles of water cohere together more strongly than they adhere to this powder, they are prevented from coming into contact with the finger and wetting it."

*W.* "I observed Caroline's fingers looked as if they had a yellow glove on, when they were in the water."

*F.* "Now let me ask you, how can a man



carry water in a handkerchief, without it's running through?"

C. "Perhaps by means of this powder. Let me try!"

Caroline strewed some of the seed over her handkerchief, gathered it up by the edges in her hand, so as to form a bag, and poured some water into it, which did not run through. "This is very curious," exclaimed she: "I could not have thought it possible."

F. "Hence, my children, you may learn, that we should not be too hasty in pronouncing a thing impossible, because we have never seen it performed. There are many things, of which you would say it is impossible, though they are perfectly natural. In the very same manner, in which you carry water in this bepowdered handkerchief, quicksilver may be carried in a bag of linen, or even of tiffany: and if you dip your fingers into a vessel full of quicksilver, they will not be wetted, or have any of the quicksilver adhere to them; because the cohesion of the particles of quicksilver to each other is stronger than their adhesion to your fingers, or to the tiffany."

## THE PLEASING PRECEPTOR.

### CHAP. III.

#### THE PASSAGE OVER THE RIVER.

ON a little excursion on foot, that William once made with his father, they came to a river, over which there was a ferry. William and his father, however, were rowed over in a boat. Playing with a ball was a favourite amusement of William's, and as they were passing over the river, he took his ball out of his pocket, and threw it up a little way, to catch it. Considering with himself, that the boat would be moving forward while the ball was ascending and falling, he supposed it must be necessary for him, to throw it a little forwards, instead of tossing it up in a perpendicular direction. It fell before him, however; and on his trying again, it did the same. A third time he threw it up, but perpendicularly, and caught it. "How is this?" said he to his father. "I thought, if I threw it up straight, as I do on shore, the boat would row away from under it, and it would fall into the water behind me."

"I will explain it to you by and by," answered his father. "At present look at

the ferry-boat, see there it goes, with a coach, and horses, and passengers, swimming along by the rope, as if of itself, without the ferryman's taking any trouble with it."

William observed it with wonder. Casting his eye in the mean time on the bank of the river, he said hastily to his father; "but whither is our boat going? See, father, that is the place where we should land, and the boatman is rowing up yonder, a great way higher up the stream, and on this side of the river. Boatman, you are going wrong."

*Boatman.* "No, no, master; the boat is going very right."

*Father.* "Let the boatman take his own course, he knows what he is about better than you.—See, he is now rowing straight across the river, but the boat descends obliquely toward the place, where we are to land. If the boatman had begun to row straight across, when we set out, we should have been drifted down much below it, should we not?"

*W.* "Yes, I see we should now."

They landed, and pursued their way. William expected an explanation of the passage over the river; for he well knew, that his

father eagerly seized every opportunity of imparting to him information respecting the things that occurred around him, if it were in his power, to give him just ideas of them; and on this occasion he was not disappointed.

“In the few minutes, that we spent in passing over the river,” began his father, “you observed several things, which you never had an opportunity of seeing before. Tell me what they were.”

*W.* “I do not understand why the ball, when I threw it straight up, did not fall behind me; or how the ferry-boat passed across the river of itself; or why the boatman first rowed us some way up the river.”

*F.* “Very well. Attention to the object itself is the first step toward attaining a knowledge of it. All three of the phenomena you have mentioned proceed from one and the same cause, which I will take this opportunity to explain to you.”

“I need not tell you, in the first place, that every motion requires a moving power. You already know, likewise, from experience, that a ball, or any other body, moves in a straight line in that direction, in which the power impels it. Thus, in playing at fives, when you move your hand in a straight line



toward the ball, and so strike it, it is impelled in that direction against the wall, if there be no obstacle in the way."

*W.* "But, father, if I throw a ball over the wall, it does not go in a straight line, but in a curve."

*F.* "That is very true; and the reason is, that the ball is not acted upon by the moving power of your hand alone, but by its own gravity likewise; for gravity is nothing else but a power, which impels a body perpendicularly to the earth. Accordingly, we have not one power acting here, but two; and this is just the case in the three phenomena you noticed during our passage over the river.

"Now when a body is impelled by two powers at the same time, which powers have different directions, it cannot follow either of these directions simply, but must take a *middle course*, in which it obeys the impulse of both powers at the same time. This you will comprehend with much more clearness and facility, if I explain it to you by a figure; and, as we have time enough to spare, we will sit down on this rising ground, and proceed to the investigation."

William pulled out his pocket-book, which by his father's advice he always carried with him, in order to make a memorandum, or take a sketch of any thing remarkable that occurred, and gave it to his father, who drew on one of the leaves the figure that follows :



*F.* " Suppose A to be our boat, and E the place at which we would land. We first rowed along the bank from A to B, our boat then came to C, to D, and so on, till at length it reached E.

" To understand why this roundabout course was necessary, we will consider the boat as at C. Here it is impelled by two powers ; the stream urges it in the direction C G, the oars in the direction C F. If it were impelled by the stream alone, in one second it

would pass from C to G ; if the water were still, so that it was impelled by the oars only, it would pass in one second from C to F ; but being impelled by both powers, it passes in one second from C to D, a middle direction between the two. The figure will show you how this direction is found."

*W.* " I perceive by the figure, that the line C D is the diagonal of a parallelogram, of which C G and C F are the sides."

*F.* " Thus to find the middle direction, which a body impelled by two powers will take, we mark the directions of the moving powers by lines, make the length of these lines proportional to the forces of the powers, complete the parallelogram, and the diagonal is the direction sought. Is it not true, that the boat, when it has reached D, has expended the impulse given it by both the moving powers ?"

*W.* " Certainly ; for it has passed down the stream as far as D, and the space F D is exactly equal to C G, through which the stream alone would have driven it ; while the space G D is equal to C F, so that it has reached exactly the same distance from the bank, as it would have done if it had been impelled by the oars only."

*F.* "Now you perceive that our boatman was very right in rowing first up the river from A to B, as in consequence we were driven down obliquely to E: and it is to be observed, that it required less exertion to row up the river near the bank, than it would have done farther out in the stream, where it's velocity was greater."

William perceived this clearly, and now wished to know, why the ferry-boat floated across the river as it were of itself.

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#### CHAP. IV.

##### THE FERRY-BOAT.

"You can tell, I presume," continued the father, "what was the moving power, that impelled the ferry-boat along the rope across the river."

*W.* "It must be the stream, I suppose; for there was no wind; and if there had been wind, the boat had no sail; and the ferryman used neither oars nor pole."

*F.* "Did you notice nothing else with respect to the boat?"

*W.* "The ferry-boat was fastened at each end to the great rope, that goes straight across the river, by a smaller rope. At the end of



each of the small ropes was a roller, that they might move freely along the large rope; and when the boat was first pushed off from the bank, the ferry-man slackened the rope at the stern of the boat, while that at the head remained as it was, so that the boat lay obliquely across the stream."

*F.* "Your observations were very accurate, and this single circumstance, the oblique position of the ferry-boat to the stream, was the cause of the motion. Had the ropes at the head and stern been equally short, so that the current had struck the side in a perpendicular direction, the boat would have remained nearly motionless; for the large rope would have prevented it's driving down the stream.

"Now, supposing the boat to be in an oblique position, and the impulse of the water to be given in the direction of  $HI$ ; if we conceive two other powers,  $HL$ , and  $HK$ , to act instead of this power  $HI$ , which is the diagonal of a parallelogram, the sides of which are  $HK$ , and  $HL$ , would not these two powers effect, precisely what would be effected by the single power  $HI$ ?"

*W.* "From what you said to me just now,

when explaining the oblique course of our boat across the river, I perceive they would."

F. "Then we may *resolve* the impulse of the water, H I, into the two *lateral powers*, H L, and H K; but can the power H L contribute any thing to the motion of the ferry-boat?"

W. "No, since it passes along the side of the ferry-boat, and therefore cannot act upon it."

F. "But H K, which is perpendicular to the side of the ferry-boat, acts wholly upon it; and this is the advantage we derive from the *resolution of an oblique power*, namely, we obtain one power, which we may leave wholly out of consideration; and another, to which we must pay all our attention. The impulse of the water, therefore, has just the same effect in moving the boat, as the power H K would have; but can the ferry-boat move in the direction H K?"

W. "No; it can only move along the great rope from H toward E."

F. "Let us then proceed to resolve H K into two other powers, H M, and H N; will not these effect, what would have been effected by H K?"

W. "No doubt they will, from what has been already said."

F. "Can the ferry-boat obey the impulse of the power H M?"

W. "No; for the great rope prevents it."

F. "The effect of H M therefore is completely counteracted by the resistance of the rope. But H N remains, for the ferry-boat can move precisely in this direction. Accordingly the impulse of the stream acts just the same in moving the ferry-boat along the rope, as any power equal to H N would do, impelling the ferry-boat across the river; and this, as you will readily perceive, as well from the left bank to the right, as from the right to the left \*, merely by presenting it's side in a different direction to the stream.

"It is now time for us, however, to resume our walk, or we shall make our journey too late."

William would willingly have heard a little more on the subject; for, by reflecting on it, a few questions had suggested themselves to his mind. He considered, when

\* The right bank of a river is that, which is on the right hand of a person, who looks *down* the stream.

the ferry-boat lies with it's side parallel to the rope, the stream cannot move it; but as soon as the stream has turned the stern round a little, it begins to advance. And, if the stern were not fastened to the great rope, it would soon be turned so far round, that the flat head would become parallel to the rope, and then it would stop. Then there must be one particular direction, in which it will make the greatest progress.

His father was greatly pleased, to find he had reflected so much on the subject; but told him, that he must acquire a little more mathematical knowledge, before it could be properly explained to him. For the present, too, his father left his curiosity unsatisfied with respect to the falling of the ball, but promised to explain it to him the first opportunity.

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## CHAP. V.

### THE TOWER.

WILLIAM'S curiosity was stimulated by the instruction his father had imparted to him. It gave him much pleasure, to learn the reasons of those appearances, that are of ordinary



occurrence. The greater number of mankind look upon such things as common and unusual, without thinking any farther about them, or imagining, that there is any more scope for thought. William's father considered it as an essential point of the superiority of a well educated person, not to be ignorant in such common things; and, in consequence, endeavoured, as far as his business would permit him, to convey information to his children respecting them, whenever an opportunity offered.

He knew from experience, that instruction thus opportunely communicated, when occasion led to it, when the curiosity of the pupil was excited by the object coming before his eyes, was more interesting, useful, and entertaining, and both imparted and received with more pleasure, than scientific and learned lessons given in systematical order. Not that he deemed such regular lessons by any means unnecessary; for he observed to his son William, then ten years old, "When you are a few years older, you will learn all this more regularly and fundamentally from proper books, and oral instruction, if at the same time you apply with industry,

and exercise your own reflection, which are the prime requisites to all learning. In the mean time, what you learn from me on our walks, or by our fireside, will be, I hope, an advantageous and pleasing initiation to you, and particularly accustom you early to exercise your own reflection; and if at any future time we should live apart from each other, as well as when I am gone from you for ever, the recollection of your early years, which you spent under the care of your parents, will be so much the more grateful to you, and you will think of me the longer, and with the more affection."

The road our pedestrian travellers took led them by an ancient tower. William was desirous of going up to the top of it, in order to have a more extensive view of the country round; and, as this might be done without danger, his father readily gratified his wish. When William had admired the prospect, he amused himself with letting the loose fragments of stone, several of which lay there, fall from the top to the bottom, to see how long they would be in falling. His father lent him his stop-watch for the purpose; and he found, that a stone took as

nearly as possible three seconds in falling to the ground.

*F.* "Can you tell me how high this tower is, William?"

*W.* "How should I know that, father, without a string long enough to measure it?"

*F.* "Do you not think, that you may learn it's height from your present amusement, letting a stone fall?"

*W.* "O, that is true. I have only to let a stone fall as far as it will in one second, and measure that height, and then I shall know it would fall three times as far in three seconds."

*F.* "Indeed you are much mistaken. Thus you see, how easily we may be led into an error, when we form a judgment hastily, and from a superficial consideration of a thing. Have you any wish, to understand the subject thoroughly?"

*W.* "Yes, certainly; for I do not like, to make mistakes."

## CHAP. VI.

## HOW DOES A STONE FALL?

*F.* "What is the reason, that a stone, when left to itself, falls perpendicularly to the ground? or, if it be suspended by a string, stretches the string in a perpendicular line? or, if held on the hand, presses upon it perpendicularly?"

*W.* "The gravity of the stone."

*F.* "At least that is the name we give this cause, of which we know nothing, but that it is a power, which continually impels a body toward the Earth, as if the Earth drew the body, or attracted it toward itself. Nothing is more common than the action of gravitation. We daily see bodies fall; the effects of this attraction of the Earth for the bodies upon it are for ever exerted around us; but for this attraction, no table, no chair, no house, would stand firm; every thing would be flying about in confusion. It is worth our while, to gain a knowledge of the laws, which regulate the action of a phenomenon of such perpetual occurrence."



IV. "I should be very glad to know them."

F. "If we consider a portion of time ever so short, the power of gravitation, or the attraction of bodies by the Earth, operates in it. Divide a second in imagination into ten parts; in the first tenth the power of gravitation would impel the stone through a short space, say a tenth part of the length of this stick. Now, if the power of gravitation acted no longer, the stone would not on that account stand still, but would continue on it's course in the same direction, and with the same velocity as before; for, *as a body at rest cannot be set in motion, without some power acting upon it, so a body in motion cannot be reduced to a state of rest, without some power opposing it's motion.* This property of bodies is called *vis inertiae*, by which nothing more must be understood, than the perseverance of a body in the state, in which it happens to be."

W. "But if I bowl a ball along the ground as hard as I can, it will at last stop."

F. "Very true; but what stops it? The unevenness of the ground, over which it rolls; the power of gravitation, which impels it

toward the Earth; and causes it to rub against the ground as it moves along; and the resistance of the air, which is so much the greater in proportion to it's velocity. Take all these obstacles away, and your own judgment will tell you, there is nothing, to stop the ball. Consider how long a ball continues rolling over a plain of ice. We are digressing, however, from our subject. To return to it, if a stone received merely the first impulse from the power of gravitation, it would continue falling, till it came to the ground; and in each tenth part of a second of time, it would fall through the same space, so that in one second it would fall through ten such spaces."

*W.* "That is clear."

*F.* "But as the power of gravitation continues to act with equal force on the body, it gives the body a fresh impulsion every instant, so that in the second tenth part of the second it would fall through two such spaces, in the third through three, in the fourth through four, and in the last or tenth part, consequently, through ten such spaces. Have you a clear comprehension of this, too?"

*W.* "Perfectly."

*F.* "Now cannot you calculate how many such spaces the stone must fall through in one second? You have lately learned how to find the sum of a series in arithmetical progression, without adding together the several members of the series; though this would not be difficult in such an easy example."

*W.* "I have only to add the first and last members together, namely, 1 and 10, multiply them by half the number of members, that is by 5, and the product will be 55. Consequently in one second the stone will fall through fifty-five tenths of the length of the stick, or a space equal to five times the length of the stick, and half the length of the stick over."

*F.* "Well, what will follow in the next second of time, which we will divide into tenth parts likewise. I fancy you are now able to calculate this yourself."

*W.* "In the first tenth part the stone will fall through 11 spaces; in the second through 12, and so on, till in the last it will fall through 20."

*F.* "And what will be the whole space

it will fall through in the second second of time?"

*W.* "That may be found as before. If I add 11 to 20, I shall have 31; and if I multiply 31 by 5, the sum will be 155. So that in the second second of time the stone will fall through 155 tenths of the stick, or 15 times and half it's whole length."

*F.* "Now take out your pocket-book, and calculate the fall for a few more seconds on the same principle."

William calculated and found

| For the        | 3d  | 4th | 5th | 6th | 7th | 8th | 9th | 1th |
|----------------|-----|-----|-----|-----|-----|-----|-----|-----|
| 1st space      | 21  | 31  | 41  | 51  | 61  | 71  | 81  | 91  |
| last space     | 30  | 40  | 50  | 60  | 70  | 80  | 90  | 100 |
| added together | 51  | 71  | 91  | 111 | 131 | 151 | 171 | 191 |
| multiplied by  | 5   | 5   | 5   | 5   | 5   | 5   | 5   | 5   |
| product        | 255 | 355 | 455 | 555 | 655 | 755 | 855 | 955 |

*F.* "Your last line, you know, consists of tenth parts of the standard we have assumed; now write down all the spaces, from the first second to the tenth, in whole numbers and fractions."

Accordingly William wrote

|         |                 |                 |                  |                  |                  |                  |                  |                  |                  |                  |
|---------|-----------------|-----------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Seconds | 1               | 2               | 3                | 4                | 5                | 6                | 7                | 8                | 9                | 10               |
| Spaces  | 5 $\frac{1}{2}$ | 5 $\frac{1}{2}$ | 25 $\frac{1}{2}$ | 35 $\frac{1}{2}$ | 45 $\frac{1}{2}$ | 55 $\frac{1}{2}$ | 65 $\frac{1}{2}$ | 75 $\frac{1}{2}$ | 85 $\frac{1}{2}$ | 95 $\frac{1}{2}$ |



*F.* "Instead of dividing the second into tenth parts, we might have divided it in imagination into hundredths, thousandths, or still smaller parts. The smaller we had taken the parts, the smaller the fractions annexed to the whole numbers would have been, as you will quickly find, if you make the trial; and if we had taken the parts infinitely small, the fractions would have been so small, that they might have been considered as nothing. If then we reject the fractions, we shall have the whole numbers

5, 15, 25, 35, 45, 55, 65, 75, 85, 95; and as all these are divisible by five, we shall find, on dividing them by this common divisor, that they are to each other as the odd numbers,

1, 3, 5, 7, 9, 11, 13, 15, 17, 19."

William had already observed this, while he was making his calculation, and was much pleased with the discovery.

*F.* "Now what law have we found for the falling of bodies?"

*W.* "That the spaces, which a body falls through in every second of time, increase in the ratio of the odd numbers."

*F.* "We have only to find, therefore,

how far a body falls in the first second, which may be done pretty accurately by experiment; and in this way it has been found, that the space a body falls through in a single second of time is about sixteen feet, or sixteen feet and an inch. Hence, if you take sixteen feet for the space passed through in the first second of time, you may easily calculate the spaces for the succeeding seconds."

William wrote down the spaces in his pocket-book, beginning with 16, and multiplying this number according to the series, first by three, next by five, and so on. Thus he obtained the following numbers in feet.

|         |    |    |    |     |     |     |     |     |     |     |
|---------|----|----|----|-----|-----|-----|-----|-----|-----|-----|
| Seconds | 1  | 2  | 3  | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
| Spaces  | 16 | 48 | 80 | 112 | 144 | 176 | 208 | 240 | 272 | 304 |

In doing this, he perceived, that the series might easily be calculated, by adding at each second 32 feet to the space gone through in the preceding.

*F.* "We will now compare the whole time, and the whole space of the fall together. If a stone in the first second fall through a given space, and in the next three times that space, how far will it have fallen in the two seconds?"

*W.* "Through four times the space of the first second."

F. "And if in the third second it fall through five times the space, how far will it have fallen in three seconds?"

W. Through nine times the space."

F. "Well, take your pocket-book, write down these numbers, and go on with the calculation for ten seconds."

William wrote

|                              |   |   |   |    |    |    |    |    |    |     |
|------------------------------|---|---|---|----|----|----|----|----|----|-----|
| Seconds                      | 1 | 2 | 3 | 4  | 5  | 6  | 7  | 8  | 9  | 10  |
| Spaces from<br>the beginning | 1 | 4 | 9 | 16 | 25 | 36 | 49 | 64 | 81 | 100 |

F. "What do you observe in these numbers?"

W. "The spaces are the squares \* of the seconds."

F. "Now, to express the spaces in feet, we must multiply them by 16, the number of feet a body falls through in the first second. Thus you have arrived at the means of answering the question, which I put to you at the beginning; and I imagine the answer you will give me now, will be very different from what you gave me then."

\* The *square* of a number is the product of that number multiplied by itself; as 16 is the square of 4, being the product of 4, multiplied by 4: and the number so multiplied is called the *square root* of the product; thus 4 is the square root of 16.

*W.* "If the stone were three seconds in falling to the ground, in this time it would fall through nine times sixteen feet, or 144 feet, so that the tower must be 144 feet high."

*F.* "This it would be exactly, according to the laws of falling bodies, which we have discovered; but you must never forget, that these will only give you an approximation to the truth, for the air resists the falling of bodies, and this in proportion to the velocity, with which they fall. From this circumstance, a stone will be somewhat longer in arriving at the ground, than if it fell through a space void of air. In dense bodies, as a ball of lead, this difference is much less, than in such as have little weight in considerable bulk, as a piece of light wood, a sponge, or a hollow globe of glass. The last would be greatly retarded in it's fall."

*W.* "I have often remarked, that a flint stone falls faster than a ball."

*F.* "In the air it does; yet in a place destitute of air both would fall with equal velocity."

*W.* "But how can we make a place to have no air in it?"



*F.* "There is a particular machine for this purpose, called an air pump, which I shall hereafter show and explain to you. In the mean time I have a question or two more to ask you, that relate to our present subject.

"What velocity will a body acquire in a given time, supposing it to fall freely?

"This question, however, is too difficult for you to give it a direct answer; we will therefore divide it a little. Supposing the second of time to be divided into tenth parts, as we did at first, how many such spaces, as the falling body passed through in the first tenth part, does it pass through in the last tenth part of the first second?"

*W.* "Ten."

*F.* "And if it continued to move with the same velocity, receiving no fresh impulse from the power of gravitation, how many would it pass through in the next second?"

*W.* "Ten times ten, or a hundred."

*F.* "Now in the first second of time, you remember, according to our calculation, it fell through 55; so that if we had taken our divisions of the second so small, as that we might have rejected the fractional parts,

we should have found the space passed through in the second second of time, double that of the first."

*W.* "That is clear."

*F.* "But if the power of gravitation had suddenly ceased to act at the end of the second second of time, would not the body have fallen through 20 times 20, or 400 spaces, in the next two seconds?"

*W.* "Certainly; for in the last tenth part of the second second of time, it would fall through 20 spaces."

*F.* "Then, as it fell through 50 in the first second, and 150 in the next, consequently 200 in the first two seconds, the space through which it falls in the second two is double what it fell through in the first two, as in the former case."

*W.* "So I perceive."

*F.* "And, if we proceed with our investigation in the same manner, we shall find, that, at the end of any given time, a falling body will have acquired such a velocity, as would carry it through double the space in an equal portion of time."

"How many feet does a body fall in the first second?"

*W.* "Sixteen."

*F.* "What then is it's velocity, or at the rate of how many feet in a second would it move at the end of the first second?"

*W.* "Thirty-two feet in a second."

*F.* "How many feet does it fall in the first two seconds?"

*W.* "Four times sixteen feet."

*F.* "Then what is it's velocity at the end of two seconds?"

*W.* "Four times thirty-two feet in two seconds, or twice thirty-two feet in one second."

*F.* "How many feet will it fall in three seconds?"

*W.* "Nine times sixteen feet."

*F.* "And it's velocity at the end of three seconds is—?"

*W.* "Nine times thirty-two feet in three seconds, or three times thirty-two feet in one second."

*F.* "Are you now aware of the general rule for finding the velocity?"

*W.* "If we multiply double the space of the fall in the first second, or thirty-two feet, by the number of seconds, we shall have the velocity acquired by the falling body, or

the space it would fall through in each succeeding second, if the power of gravitation did not continue to act upon it. For instance, in three seconds it will acquire a velocity of ninety-six feet in a second."

## CHAP VII.

### THE SKITTLE-GROUND.

*Father.* "We have lately investigated the laws, William, according to which a body falls to the ground, when it can fall freely, that is, perpendicularly, and without hindrance. Let us now consider the descent of a body on an inclined plane. For example, *how does the bowl roll down the run of a skittle-ground?* In order to find this, we will draw the following figure.



"Let  $AC$  be the inclined surface of the run:  $AB$ , it's height:  $BC$ , the base, or the



In  $e$  the run would make if it were horizontal; and  $D$ , the bowl. Suppose, if the bowl were free to fall, it would fall perpendicularly in a given time through the space  $DG$  by the power of gravitation. This line  $DG$ , then, may represent the power of gravitation at the commencement of the motion of the bowl. What think you; will not this power be in part diminished?"

*W.* "Certainly; for if the run were horizontal, it would be completely destroyed; but, as the plane is inclined, it will be so only in part."

*F.* "Cannot you render this a little more clear by the resolution of the power?"

*W.* "We must resolve the power  $DG$  into two, one of which will be entirely destroyed, the other remain."

*F.* "Very well; go on."

*W.* "The first, therefore, must be perpendicular to the run, as  $DF$ , which will of course be destroyed by the resistance of the run; the other  $DE$  must be in the direction of the run, so this will have nothing to obstruct it."

*F.* "Then the absolute gravity of the bowl, will be to it's *relative* gravity, so we call

the power by which a body is impelled along an inclined plane, as  $DG$  to  $DE$ ."

*W.* "Evidently."

*F.* "Now consider the triangles  $DEG$ , and  $ABC$ , you will find they are similar; for the angles  $A$  and  $D$  are the opposite angles of the two parallel lines  $AB$  and  $DG$ ; and the angles  $E$  and  $B$  are both right angles. You have made sufficient progress in geometry to understand this, and to infer from it a proportion, which may be of service to us."

*W.* "It follows, that  $DG$  must be to  $DE$ , as  $AC$  to  $AB$ ."

*F.* "What may we infer from this?"

*W.* "That the absolute gravity is to the relative, as  $AC$  to  $AB$ ; that is, as the length of the inclined plane to it's height."

*F.* "Now suppose the inclined plane were 32 feet long, and 8 feet high, how many feet would the ball roll down in the first second of time?"

*W.* "As the height is exactly a fourth part of the length, it would descend a fourth part of the space it would fall through, if free, in the first second of time; that is a fourth part of sixteen feet, or just four feet."

*F.* "I need not remind you, that the

proportions would remain the same in the second, third, fourth, and following seconds. For if *D G* represent the fall in the second second of time, or forty-eight feet, *D E* would represent the descent on the inclined plane, which, according to the measures we have assumed, would be twelve feet. What spaces therefore would the bowl descend through in each successive second?

*W.* "The spaces 4, 12, 20, 28, 36, 44, and so on. To carry the series further, we need only continue to add 8 each time."

*F.* "And what would be the spaces descended through, reckoning from the beginning?"

*W.* "4, 16, 36, 64, 100, 144. To continue the series, the number of seconds must be multiplied by itself, and the product, or the square of the time, must be multiplied by the length of the descent in the first second."

*F.* "You see, then, that the law of descent remains the same, as when a body falls freely: hence you will find no difficulty to tell me what velocity the bowl must have at any given instant."

*W.* "In this case, as in that of a body

falling freely, we must multiply the number of seconds by double the descent in the first second; in our example, therefore, by eight. For instance, the velocity acquired by the bowl on this plane in three seconds would be that of twenty-four feet in a second."

*F.* "Consequently, in the case we are considering, it will always be the fourth part of the velocity of a body falling perpendicularly.

"Now let us inquire, how much longer time the bowl would take to descend down the inclined plane from A to C, than to fall perpendicularly from A to B.

"We formerly found the height of a perpendicular fall, as you may remember, by multiplying the square of the time by sixteen: the sixteenth part of the height, therefore, must be equal to the square of the time; must it not?"

*W.* "That is obvious."

*F.* "And we found the descent on our inclined plane by multiplying the square of the time by four: so that the fourth part of the descent must be equal to the square of the time."

*W.* "That is equally clear."



*F.* "In our figure, therefore, we should find the square of the time, in which the bowl would fall through *A B*, if we expressed *A B* in feet, and divided the number by sixteen, or took the sixteenth part of *A B*.

"And the square of the time, in which the bowl descends along *A C*, if we took the fourth part of *A C*.

"But in our figure *A C* is just four times as great as *A B*: how many times, then, must the fourth part of *A C* be greater than the sixteenth part of *A B*?"

*W.* "That may easily be reckoned. In equal lines the fourth part of one would be four times as great as the sixteenth of the other; but as *A C* is four times as great as *A B*, the fourth part of *A C* must be just sixteen times as great as the sixteenth part of *A B*."

*F.* "Is not this the same thing, in other words, as to say, that the square of the time in which the bowl descends along *A C*, is sixteen times the square of the time of it's falling from *A* to *B*?"

*W.* "Certainly."

*F.* "But if the square of one number be sixteen times as great as the square of ano-

ther, how many times as great as the smaller number itself would the larger number be?"

*W.* "Four times as great."

*F.* "What have we found then?"

*W.* "That the bowl would take four times as long to descend from A to C, as to fall from A to B."

*F.* "Very good. But again: how did we find the velocity which the bowl acquired in descending from A to C?"

*W.* "We multiplied eight feet by the number of seconds, which it required to descend from A to C."

*F.* "And how should we find the velocity it would acquire in falling perpendicularly from A to B?"

*W.* "By multiplying 32 feet by the number of seconds it would be in falling."

*F.* "Do you remark nothing particular here?"

*W.* "O yes! These velocities are equal: for 8 feet is just a fourth part of 32, and on the other hand the time of descending from A to C is four times that of the falling from A to B."

*F.* "Here then we have discovered an important law: *a body descending on an in-*

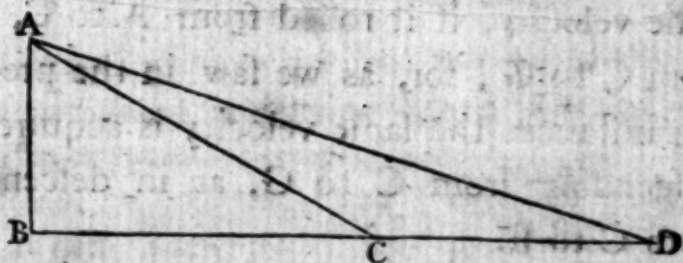
### THE PLEASING PRECEPTOR.

*clined plane acquires, at every point, the same velocity, which it would have acquired, if it had fallen through a space equal to the perpendicular height of the point, whence it began to descend, above the point, at which it is arrived.*

“ We will deduce a corollary or two from this law.

“ In the first place, the velocity, which the bowl acquires, is uniformly the same for a given perpendicular height, whatever may be the inclination of the plane down which it rolls.

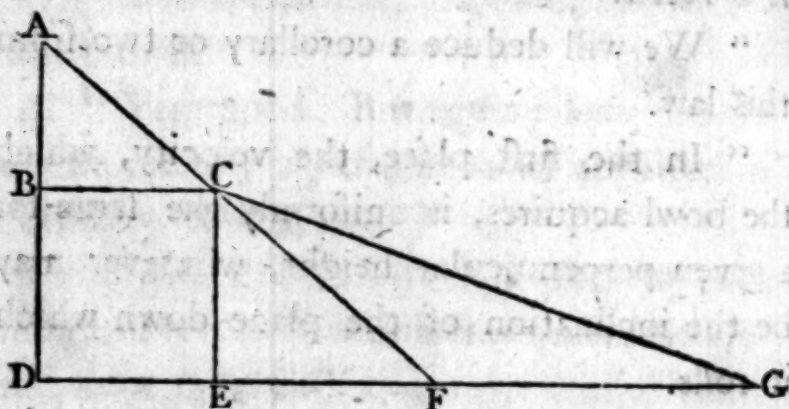
“ For example, the bowl would acquire just the same velocity, whether it rolled down A C, in the figure following, or the less steep inclined plane A D.



“ Is this clear to you ?”

W. “ Yes ; for in each case it's velocity must be the same, as it would have acquired in falling perpendicularly from A to B.”

*F.* “Secondly, the velocity of the bowl will be the same, whether it roll down a single inclined plane, or one composed of several with different inclinations. For example, let us draw the following figure.



“Now, if the bowl roll from A through C to F, it will have acquired the same velocity, as if it had fallen perpendicularly from A to D. And it would acquire precisely the same velocity, if it rolled from A to C, and from C to G; for, as we saw in the preceding instance, the same velocity is acquired in descending from C to G, as in descending from C to F.

“I need not observe to you, that the conclusion will be exactly the same, whether two planes, or several, with different inclinations, succeed each other, and whether the first or last plane be the more steep.



“ This is just the fact in the slope of the skittle ground, which rarely has the same inclination throughout, and it's inclination is still more varied by the oblique direction the bowl takes \*.”

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## CHAP. VIII.

### THE BALL.

WILLIAM, eagerly desirous of improving his knowledge, reminded his father, that he had promised to explain to him the throwing up of the ball.

\* I am almost afraid, that the lessons William has here received from his father, on the phenomena of gravitation, may appear a little dry to a few of my readers; yet they were necessary previous to some of the following articles: I have delivered them in such a way, as not to be above the comprehension of a youth at all accustomed to reflection; and I have too good an opinion of my young readers, to suppose them desirous of being amused merely, without being instructed. A little reflection, a little application, my dear young friends, must not frighten you, if you would acquire useful knowledge. Believe me, the acquisition of knowledge will amply reward you, for all the exertion you may bestow in it's pursuit.



would the power of gravitation act upon it in this time?"

*W.* "It would depress it four times sixteen feet, that is sixty-four feet."

*F.* "Consequently it would not arrive at C, but at B; thus, if C be sixty-four feet high, reaching the ground. If you draw the figure larger, you may divide the line of projection into more equal parts than I have done here, and thus obtain the curved line, which the ball describes in passing through the air. Thus, the ball impelled by the hand alone would reach the point I, midway between A and F, in half a second; and in the same time the power of gravitation would depress it one-fourth of sixteen feet, that is four feet. These four feet being set off on the perpendicular I H, we should find the point N, at which the ball would arrive in half a second."

*W.* "Might we not draw the curve line with a pair of compasses?"

*F.* "No: it is a line of a different kind from that of the circle, with the properties of which I shall hereafter make you acquainted, when you have advanced farther in the science of geography, for which, to my great satisfaction, you show so much aptitude. At present I shall only tell you the name of this

curve ; it is called a *parabola*. But will the ball proceed in fact precisely in this line ?”

*W.* “ Probably the resistance of the air will make some alteration here too.”

*F.* “ It will ; and a very perceptible one. Hence experiments of this kind will never be found to coincide exactly with the calculation.

“ By this time, I imagine, you are able to perceive, why a ball, when thrown straight upwards by a person sailing in a boat, or riding in a carriage, falls down into his hand again, as well as if the person stood on the ground.”

*W.* “ The ball in this case is acted upon by three powers: by the hand, which impels it directly upwards ; by the boat, which impels it horizontally ; and by the power of gravitation, which acts upon it perpendicularly.”

*F.* “ Right. Suppose then that the hand in A impels the ball with a force that would make it ascend perpendicularly 32 feet, or to E, in one second, and that the boat moves from A to G in one second ; these two powers, A E and A G, acting on the ball, would carry it through the diagonal line A F : in the mean time the power of gravitation would depress it to M, where it would be in the middle of the throw ; and



at the end of the throw it would be brought by the joint-action of these three powers to B, whither the hand would be brought at the same time by the boat."

*W.* Now I understand very well, why the ball fell before me, when I threw it a little forwards."

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## CHAP. IX.

### SHOOTING AT A MARK.

"TO-DAY there is to be shooting at a target, and at a wooden bird," said William eagerly to his father one morning.

*Father.* "You speak as if you would willingly go to see it; do you not?"

*W.* "If you will give me leave, father."

*F.* "Very readily, William, under one condition, that you keep close by my side. You may imagine, that it is an exercise not unattended with danger; and it is much to be wondered, that we do not more frequently hear of accidents occurring at it; for sometimes the places chosen for the purpose are very near gardens and public roads, so that the balls have passed over the heads of people going by, as once happened to myself; and children are apt to run very heedlessly

near the target. You, I expect, will take care of yourself; for though I would by no means have a boy afraid of a gun; or run away when he hears one discharged, I can as little suffer giddiness and imprudence with respect to fire-arms. In one of your Latin lessons lately you read an anecdote of Diogenes, which, I presume, you will not think of imitating. Do you remember the story, to which I allude?"

*W.* "Yes. Diogenes, seeing an unskilful shooter exercising with the bow, went and sat down close to the mark. One of the bystanders calling out to him, and asking why he placed himself there, Diogenes answered, 'That the arrow might not hit him.'"

*F.* "Let me observe to you, on this occasion, the philosopher did a *mad* action; in order to have an opportunity of making a *witty* speech. Never do you follow his example."

William, delighted with the idea of the pleasure he expected to enjoy in the afternoon, was withdrawing to his regular studies, when his father observed to him, that the afternoon's diversion would afford him an opportunity of proposing a question or two for his son to resolve.

“ That will give me so much the more pleasure,” answered the good youth.

Accordingly, when the afternoon arrived, Mr. Goodwyn repaired with his son to the field. Several shots missed the mark; whenever one hit it, the sound of the drum announced it to the spectators. The drum beat, likewise, previous to every shot, as a warning to the company, to keep themselves out of the way of danger; but this was far from sufficiently heeded by many. William kept close to his father, in a place perfectly safe, and enjoyed the shooting, the music, and the sight of such a concourse of people, assembled on a fine day to partake in the general festivity. Piece after piece dropped from the wooden bird, which was placed at the top of a high pole; the diversion ended with the approach of night; the crowd gradually dispersed; and William returned home with his father.

“ Would that powder and shot were never more to be employed, but for amusement !” exclaimed Mr. Goodwyn: “ that balls henceforward were to pierce only targets and wooden birds, not kill or wound men !”

“ I cannot think how men should ever

go for soldiers, and make war upon one another," said William.

*F.* "Do not be too hasty in your judgments, William; a soldier, considered in a proper light, is an useful member of society; and war, with all its horrors, has its good effects, though in most cases I am far from its advocate. Of this, however, another time. But now tell me, have you seen any thing, which you are desirous of having explained?"

On the present occasion objects had so crowded upon William's eyes and ears, that these almost alone had been employed, and he confessed, he could think of nothing, that he had to ask his father.

*F.* "This is just what I expected, my dear William; and therefore I shall put one or two questions to you, on which you may reflect, and consult your books, till morning.

"How is it, that, when good aim is taken, and the piece is held firmly, the ball hits the mark?"

"How is it, that gunpowder has such great force? of what is it made? and when was it invented?"



At the first question William looked on his father with a smile, as much as to say, "a very puzzling question truly!" To the second he expected to find an answer in some of his books.

## CHAP. X.

## THE RIFLE-BARRELLED GUN.

*Father.* "WELL, William, are you ready with your answers to the questions I put to you yesterday?"

*William.* "Only in part. If you had asked me, why, when good aim is taken, and the piece is properly fired, the ball sometimes misses the mark; I should have answered, because the gun was not well made."

*F.* "Let us then consider the question; as I put it to you yesterday, a little more closely. What is it a man does, when he takes aim at an object with his gun? You know I have already allowed you to shoot with one sometimes, as I would have you learn how to handle such a thing, and to manage it with *prudence*."

*W.* "He places his eye behind the groove in the breech of the piece, and levels the barrel so that the sight, or knob near the end of it, and the object he wishes to hit, are both in a direct line with the groove."

*F.* "The barrel, then, is pointed in a direct line to the object?"

*W.* "Certainly."

*F.* "And so the ball, when the gun is fired off, will fly in a direct line to the object?"

*W.* "To be sure; and therefore must hit it, if the gun be not moved out of it's direction in pulling the trigger."

*F.* "But I should have thought, that the power of gravitation would act upon the ball in it's course, and depress it, so that in such a case it would not hit the mark, but fall far below it. Have you forgotten the conversations we have lately had on the subject of gravity?"

*W.* "O no. But the force of the powder is so great, that the power of gravitation cannot depress the ball perceptibly out of the right line, as it flies with such velocity. The moment we hear the report of the gun, we see the ball has hit the target."

*F.* "Just so have I heard others express themselves, and indeed persons who might be supposed to understand the subject, as they scarcely pass a day without having a gun in their hands. In you it is very excusable. But then how is it, that, when the piece is well aimed, and properly fired, the ball sometimes flies over the mark, not under it? and how is it, that the same piece, well fired, and with precisely the same charge, at a certain distance hits the mark, at a greater distance shoots under it, and at a less shoots over it?"

*W.* "I do not know, but no doubt you can tell me."

*F.* "You must be aware, however, that, if the ball proceeded in a direct line to the mark, it must hit it at a less distance as well as at a greater."

*W.* "To be sure."

*F.* "But it has been found by repeated experiment, that, with a good rifle-barrelled gun, and the usual charge of powder, which is about the fifth part of the weight of the ball, if the barrel be levelled directly at the mark, the ball will pass about a foot below it, supposing the mark to be at the distance

of fifty yards. What may we infer from this?"

*W.* "That the power of gravitation has depressed the ball thus much; and that consequently the ball, in passing through the air, has described that curve line, which you lately called a parabola."

*F.* "Now let me ask, must the barrel be levelled directly at the mark, if you would hit it?"

*W.* "No: but ——"

*F.* "Tell me, then, how it must be levelled, and what is done in taking aim. Here, look at this gun, examine it attentively, particularly the breech and the sight. What do you observe?"

*W.* "That the breech is higher than the sight."

*F.* "It is so; for the barrel of the gun is thicker at the breech than at the muzzle, so that the sight is nearer to the axis of the barrel, or a line that would pass through its centre."

*W.* "Now, I believe, the difficulty is as good as solved."

*F.* "I will proceed to explain it. Let the eye be at *O* in the figure, the upper



edge of the breech at V, the sight at K, the mark, or centre of the target, at Z. Now if O V K Z be in a direct line, and, as we will suppose here, in a horizontal one, the axis of the barrel will not lie horizontally, but inclining a little upwards, so that the ball, if it proceeded in a straight direction, would arrive at L, but, being acted upon by the power of gravitation, it proceeds in the curve K S Z, and thus hits the mark. In the same manner, when the piece is discharged from P at the bird on the pole in Q, the end of the barrel is directed higher, toward R, and the ball describes a curve from P to Q."

W. "I now perceive, why a gun, with a given charge, can carry true only at a certain distance; for if the target be nearer, as at X, the ball will be above the line of aim, O Z, when it reaches the distance of the target, and consequently will pass over the mark; and if the target be farther, as at Y, the ball will be below the line, and pass under the mark."

F. "How then should we manage, to adapt a gun to a greater distance, or a less?"

IV. "For a less distance the sight must be

made higher, that the path of the ball may deviate less from the line of aim, and intersect it sooner; and for a greater distance the sight must be made lower."

*F.* "The same purpose may be effected by a moveable sight, which is to be drawn back, or nearer to the eye, for the shorter distance; so that the axis of the barrel may form a more acute angle with the line of aim, and the ball, in consequence, deviate less from it. For a remoter distance, on the contrary, the sight is to be pushed farther forward. This, however, can be of little use, except in shooting at a fixed mark, the distances of objects in the field too frequently varying, and often not allowing the shooter sufficient time for such adjustments. To shoot well, therefore, a man should be a good judge of distances by the eye, and take his aim a little above the object, when it is beyond the distance for which the sight of his piece is calculated, and proportionally below it, when the object is at a shorter distance."

## CHAP. XI.

## GUNPOWDER.

WITH respect to the invention and composition of gunpowder, William could only find, that a monk, of the name of Berthold Schwarz, in the fourteenth century, was said to have pounded together some saltpetre, sulphur, and charcoal; that a spark from his candle accidentally fell into the mortar; and that the mixture from this caught fire, and blew the stone, that covered the mortar, up into the air.

*Father.* "This was long the current opinion: but it is now known, that the invention must have been much earlier. Roger Bacon, who was born in 1214, and died in 1294, and was deemed a conjuror by the ignorant people of those days for the great superiority of his knowledge, has a much stronger claim to the invention than Schwarz; for in his works the composition of gunpowder is described, though in an enigmatical manner, no doubt from an apprehension of the mischievous purposes, to which it might

be applied. But even in the twelfth century, which was prior to the birth of Bacon, gunpowder was used in the mines of Goslar, in the Harze, to blow up rocks; and in the year 1200, the son of Henry the Lion employed it to blow up the walls of a fortress at the siege of Tyre. From the thirteenth century it was applied to the purposes of war; though at first only for blowing up walls, as at the siege of Algeziras in 1341. The practice of shooting stones and balls to a distance with it seems to have been first adopted in the middle of the fourteenth century. In the year 1346, at the battle of Crecy, the english used a sort of cannons, which were then called thunder-boxes. At the end of the fifteenth century it was employed for mines. These are subterranean passages, ending in a chamber, which is filled with powder, in order to blow every thing over it into the air. We read, too, of muskets, arquebusses, and pistols, in the fifteenth century; but, you may suppose, they were not then brought to such perfection, as they are at present. In China gunpowder is said to have been known much earlier than it was in Europe; and it is probable, that a know-



ledge of it was brought from this country into Europe by the Arabs."

*W.* "Horrible invention! How many men have been killed, mangled, and crippled by it! Do not you remember the poor old soldier, that we saw begging the other day, with only one arm and one leg?"

*F.* "I do. Yet, before powder, and balls, and bombs, were invented, wars were still more bloody. Let us hope, that a time will come, when war will only be read of in history, not known by experience: yet neither I, nor you, probably, will live to see the time.

"To return, however, to the composition of gunpowder, of which I will give you some account. The several ingredients you just now mentioned. Formerly it was usual to compound them in different proportions, according to the pieces for which the powder was intended: as for mortars, 100 parts of saltpetre, and of sulphur and charcoal twenty-five each; for great guns, 100 parts of saltpetre, fifteen of sulphur, and eighteen of charcoal; for small arms, 100 parts of saltpetre, eight of sulphur, and ten of charcoal. Of these the first makes the weakest powder; the last, the

strongest. Now, however, it is usual to make one kind of gunpowder for both great and small arms; and our proportions are six parts of saltpetre, one of sulphur, and one of charcoal.

“ These ingredients are ground together in mills to a very fine powder, which is called meal-powder: this is moistened with water, and made into a stiff paste; and this paste is forced through wire sieves, which give it the form of grains, or corns. In this state the powder is carefully dried; after which it is put into a barrel, which it fills only in part, and the barrel being turned round for some time horizontally, the corned powder acquires a polished surface by the friction of the grains against each other. Thus we have those little grains, which carry death and destruction to a distance, that no weapon of preceding ages could reach, and imitate in miniature the most tremendous phenomena of nature, thunder, lightning, and earthquake.

“ The goodness of powder depends on the purity of the ingredients, their being intimately mixed and properly granulated, and the proportion of saltpetre being as much as

can be inflamed or detonated by the sulphur and charcoal; for the cause of the immense power exerted by gunpowder is properly in the saltpetre."

*W.* "I imagined, the strength of the powder lay in the flame; as you once told me, that air was greatly expanded by heat."

*F.* "This alone could by no means effect what we see performed by the inflammation of gunpowder; and it may be considered as an unquestionable fact, that, on firing gunpowder, an extremely elastic aeriform fluid, or *gas*, is evolved, which arises principally from the detonation of the saltpetre. Some future day I will show you an experiment with the air-pump, from which this may clearly be inferred. Remember to put me in mind of it. This aeriform fluid has been found to occupy 250 times, or, according to others, 500 times the space of the gunpowder, from which it was evolved, without taking into the account any expansion from heat. Thus from one cubic inch of gunpowder are produced 250, or 500 cubic inches of *gas*, which must be expanded to four times this bulk, at least, by the heat generated in firing the powder. Confe-

quently the *gas* evolved strives instantaneously to expand itself into a space one or two thousand times as large, as that which the charge of the piece occupied. Hence you may readily account for the extraordinary force of powder."

W. "I should like to know how far a cannon will shoot a ball."

F. "That depends on the size of the cannon, the quantity of the charge, and the angle the axis of the cannon makes with the horizon. I will give you a couple of instances, however, which, no doubt, will exceed your expectation. An eighteen-pounder, or cannon carrying a ball of the weight of eighteen pounds, when loaded with nine pounds of powder, and elevated to an angle of forty-five degrees above the horizon, will throw it's shot to the distance of 19000 feet, or upwards of three miles and a half. This is the range of it's greatest *random-shot*. If levelled horizontally, it will carry *point-blank*, that is so as not to deviate strikingly from a right line, about 1900 feet, with the same charge.

"The velocity with which the ball is driven out of the cannon may be considered as from 1400 to 1700 feet in a second.



“ If a cannon be fired against a wall of earth at the distance of 200 yards, it will bury the shot fifteen or sixteen feet deep : if the wall be of brick, the ball will penetrate it but little more than a foot.”

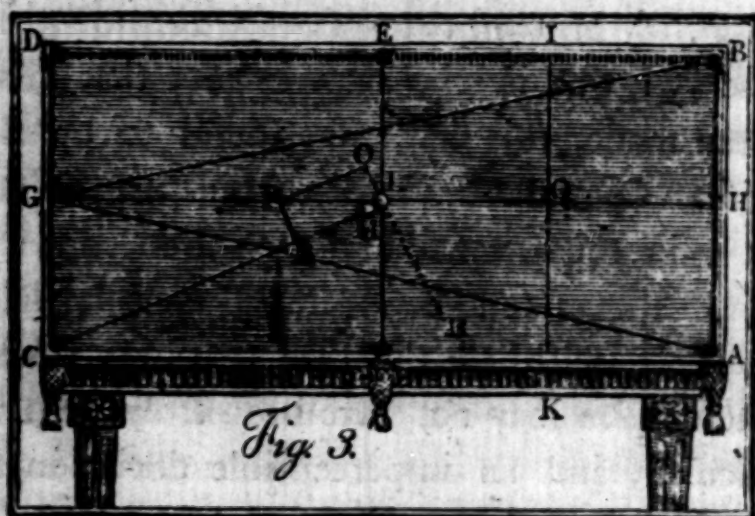
This extraordinary force appeared astonishing to William. Presently he asked his father, whether, if a cannon were discharged perpendicularly, the ball would not fall back into it's mouth ?

*F.* “ It ought to do so according to theory : yet in the experiments that have been made, this never was found to be the case. Cannons have been fixed perpendicularly in the ground, and then fired, but the balls always fell considerably on one side. Possibly, with all the care that was taken, the cannon may not have been truly perpendicular ; and an imperceptible deviation in the position of the cannon would occasion a considerable deflection in the path of the ball, from the height to which it ascends. Possibly, the piece might be so shaken by the explosion, as to occasion the deviation observed, though it may have been placed perpendicularly. Or it is possible, that the motion of the air may have deflected the ball out of the right line. But we have said

enough on the subject of these murdering instruments. The physical and mathematical investigations, in which they exercise the mind, and which have occupied the attention of men of considerable genius, are in fact the best things belonging to them."

## CHAP. XII.

### BILLIARDS.



A LITTLE way out of town was a tea-garden, in a pleasant situation, whither William's parents sometimes went for a walk. At this house was a billiard-room, into which Mr. Goodwyn and his son sometimes went as spectators. William was much amused with the game, and requested his father, to teach him to play at it. Mr. Goodwyn

promised him he would, the first time they happened to be there alone.

Many of my young readers, no doubt, have seen a billiard table. They who have not should be informed, that it is a parallelogram, about twelve feet long and six feet wide, covered with a green cloth, surrounded with a rim about two inches high, and having six holes, to which pockets of netting are affixed, one at each corner, and one in the middle of each of the larger sides. Each of the players has an ivory ball, and a mace, or a cue, with which he impels it along the table. The mace consists of a flat wooden head, the end of which is a straight line at right angles with the stem; and the stem, or handle, a slender stick, about three feet long. The cue is a simple stick, about the same length, somewhat more than an inch in diameter at one end, tapering uniformly to about a quarter of an inch at the other, and cut flat a little way on one side of the larger end. The principal object of the player is, so to strike his own ball with the mace, or cue, that it shall hit his adversary's ball, and drive it into one of the pockets; his own ball at the same time remaining on the table.

To teach the laws of the game is not our

object here : there are other books, in which they may be found ; and it is one of those games, which is to be learned gradually by practice, rather than by description. It is however a very amusing and healthy pastime. It exercises the body moderately and variously, and is therefore particularly salutary to those, whose way of life obliges them to sit much. The eye and the hand likewise are exercised at it ; and it does not leave the mind unemployed.

It is not suited for every one, however, as a billiard table is an expensive article, and the players must pay the owner of it for its use. Many, too, are addicted to it in excess, and spend a great deal of time at billiards, which they might employ to much more advantage ; and when, as too often happens, the game is played for money, sometimes indeed for considerable sums, it is a dangerous and ruinous game, and as injurious both to the body and mind of the player, as it is beneficial to them when resorted to in moderation, and for recreation alone.

William was cautioned by his father accordingly, that he might not become too



strongly attached to the game, and so squander at a future period too much of his time and money. After he had learned the proper position of the body, how to place his left hand on the table, the manner in which the small end of the cue was to be supported on the thumb and forefinger, and the proper management of his right hand in order to give the stroke, his father taught him how to strike his ball, to make it rebound from the cushion so as to lie where he wished it, or to hit his adversary's ball with it, and drive it into one of the pockets.

That what I shall have occasion to say may be intelligible to those of my young readers, who have never seen a billiard-table, I have given a delineation of one. A B C D are the four corner pockets, E and F the two middle pockets. On the border at I and K are two brass nails, called the stringing nails, between which an imaginary line is drawn, called the stringing line. The space A B I K, within this imaginary line and the end of the table, being one-fourth of the whole table, is named the balk.

William, who had an accurate eye and a steady hand, soon learned how to play; but

the question frequently occurred to him, "why must I play the ball in such or such a manner?"

"Very few billiard-players," observed his father, "know any thing of the laws of percussion. Indeed a man perfectly acquainted with them may be a very bad player at billiards; and a person totally ignorant of them may be a very good one. Yet, if a man, who has a certain degree of practical dexterity, understand the principles of what he does, it is so much the better, and not useless to him in the execution of it. If we suppose two players in other respects equal, that is, with equal accuracy of eye, steadiness of hand, and practice at the game, one of whom adds a knowledge of the theory of percussion to his experience, while the other has no guide but his experience alone, the former will unquestionably beat the latter. The former acts from clear views; the latter has only an obscure presentiment of the effect. The former will err less frequently than the latter. When we get home, I will give you a few explanations of the rules, which I have been pointing out to you to-day in practice."

## CHAP. XIII.

## CONTINUATION.

*F.* “WE will first consider the stroke with a single ball. When you play this against the cushion, it rebounds, as a ball does when thrown upon the ground or against a wall. What is the reason of this?”

*W.* “I do not understand clearly why it should do so.”

*F.* “I will tell you. A ball is elastic: consequently, when any of it's particles are forced out of their place by pressure, so as to alter the figure of the ball, they strive to return to it again. Thus, when you throw your ball upon the ground, the part that touches the ground is pressed flat, and endeavours to return to it's former figure, with a force proportional to that which was employed in compressing it: but this force cannot be spent on the hard and unyielding ground, and therefore drives the ball upwards. If you make a ball of any inelastic substance, as lead, or wet clay, and throw it upon the ground as hard as you will, it

will not spring up, because the part that is flattened does not strive to recover it's former shape."

*W.* " But I did not think an ivory ball, like that with which we play at billiards, could be compressed."

*F.* " There you were greatly mistaken. You are not able to compress it with your hand, it is true ; but a blow or fall, will compress it, as I will show you. See, I will take a little grease and spread it here on the table, and lay this ivory ball gently upon it. You can see the place where it touched the table by the mark left in the grease. Now I will let it fall upon another place. What do you observe ?"

*W.* " That the mark, which the ball has now made in the grease, is bigger than that, which it made when it was laid gently upon it."

*F.* " I need not ask you what this proves."

*W.* " It proves, that a larger portion of the ball has touched the table ; consequently, it must have been somewhat flattened."

*F.* " It is just the same in playing at billiards : though here the rebound of the ball is not owing to it's elasticity solely, but in a



much greater degree to the elasticity of the cushion, which is well stuffed.

“We will now consider the straight stroke against the cushion, and the oblique.

“If you strike the ball *straight* against the cushion, as from Q to G for example, the ball will return in the same line, and you may continue striking it in the same direction as often as you please; though it must be owned, it requires a steady hand to strike it so twice following.

“But if you strike the ball *obliquely* against the cushion, as from A to G, the ball will return in the line G B, which makes the same angle with the cushion C D, also with the perpendicular line H G, as the line A G, in which you struck the ball.

“Is not this susceptible of a demonstration?”

W. “I should suppose so, from a resolution of the powers?”

F. “Certainly. We may express the power of the stroke by the line A G, and resolve it into two lateral powers, one, A H, parallel with the cushion C D; the other A C, perpendicular to the cushion. The former is not obstructed by the cushion;

the latter is totally destroyed by it, and changed to it's opposite by the action of elasticity.

“As soon as the ball has touched the cushion *G*, it is again impelled by two powers. It's own elasticity, and that of the cushion, act upon it in the direction *G H*, perpendicular to the cushion; that power of the stroke which was not destroyed acts upon it in a direction parallel to *G D*; consequently it must describe the diagonal *G B*. But are not the triangles *A G H*, and *B G H*, perfectly similar?”

*W.* “Yes; for the side *G H* is common to them both, *A H* and *B H* are equal, and the angles at *H* are the same in both, each being a rectangle; but if two sides of one triangle, and the angle between them, be equal to two sides of another and the intermediate angle, the two triangles must be alike; and, of course, the angles at *G* must be similar.”

*F.* “Very right. We know now, therefore, the law, according to which the ball rebounds from the cushion, namely, at the same angle, under which it was played against it. This law will guide a man,

when he has to play a *bricole*; that is, to play his ball first against the cushion, so that it may come after the rebound to the place intended. When the player hits his adversary's ball so as to make it rebound from the cushion to the place intended, it is called *cushioning*. To execute either of these properly, requires an accurate eye; and this will be guided and assisted by a knowledge of the law we have just investigated."

#### CHAP. XIV.

##### CONTINUATION.

*Father.* "We will now consider the striking of one ball against another, first in a straight line, then in an oblique direction.

"When a man plays straight at his antagonist's ball, or so that the line in which he strikes his own ball passes through the centre of his antagonist's, the latter is propelled precisely in this direction. This is called hitting a ball *full*. When the adversary's

ball lies in a direct line between the player's ball and a pocket, it is said to be a *full ball*.

“ But when the adversary's ball does not lie in a straight line between the player's and a pocket, it commonly requires striking obliquely, to which we will proceed. Suppose, for example, your ball is at *Q*, your adversary's at *M*, and you would put it into the pocket *C*, your stroke must be guided by the following rule. Imagine a right line, *C M*, passing from the hole through the centre of your adversary's ball; your own ball must be played in such a manner, that the point where it hits your adversary's must be in the line *C M*, or so that, at the moment when the balls come into contact, the centres of both balls and the hole may be in a right line, *L M C*. For when struck obliquely, as well as when struck full, the ball that is struck will be propelled in a line passing through the centres of the two balls at the instant of contact.

“ To perceive this clearly, you need only express the force of the stroke which your ball gives your adversary's by a straight line, say *L P*, and resolve this into two lateral powers, one *L N*, perpendicular to the point



in which the balls touch each other,  $LO$ , parallel to a tangent drawn through the point of contact. What conclusion may we draw from this?"

*W.* "The lateral power  $LO$ , which merely passes by the adversary's ball at the point of contact, can contribute nothing to it's motion; on the other hand, the power  $LN$ , which is perpendicular to the point of contact, acts wholly upon the ball, which must consequently move in the direction  $LN$ ."

*F.* "You will, no doubt, be aware yourself, that the oblique stroke has it's limits. For instance, do you suppose it possible, to hole the ball  $M$  in the pocket  $C$ , if you play your own ball in the direction  $RO$ ?"

*W.* "No; for then my ball would pass close by the ball  $M$ , without touching it so as to move it out of it's place."

*F.* "What then is the extreme, that limits the oblique stroke?"

*W.* "It is the stroke in which the direction of the player's ball makes a right angle with that which his adversary's should take."

*F.* "Right! the angle which the direction of the player's ball makes with that

which his antagonist's should take, must always be an *obtuse* angle. When it is but little obtuse, or approaches a right angle, the adversary's is said to be a *fine* ball, and the player is said to *hit it fine*, or *cut* it. The less the angle exceeds  $90^{\circ}$ , the finer the cut.

“A *perfectly full* ball, or a *dead full* ball, as it is commonly called, and a *very fine* ball, are the most difficult to play. A ball at a moderately obtuse angle is easier.

“What we have considered hitherto, refers merely to the direction the ball played upon is to take. How far it will run, and where the player's ball will lie after the stroke, cannot be determined in such a general way; for these will depend on the strength of the stroke, and the weight of the ball. They will form subjects for our consideration at some future time.

## CHAP. XV.

## HANGING A BUCKET ON A TOBACCO-PIPE.

"Is it possible, father?" said William, as he came running in; "John says, he can hang up a bucket of water upon a tobacco-pipe, and not fasten the tobacco-pipe too."

F. "Desire John to let you see him do it; that is the best way of being convinced."

Accordingly John was ordered to come in. He laid a tobacco-pipe on the table, so that a very little of the end of the pipe projected over the edge of it, and hung the bucket of water by the handle upon this end, by which it was supported.

F. "You have now learned from John, how it is to be accomplish'd; but I apprehend it will be necessary for me, to give you an explanation of it. The principle on which it is founded is that of the *lever*; without being acquainted with this, we cannot form an accurate judgment of some of the commonest things. By a lever we understand a pole, or any other solid substance, acted upon in two different points by sepa-

rate powers, which endeavour to move it round a third point in opposite directions. When this third point, or centre of motion, called the *fulcrum*, is between the other two, at which the moving powers act, it is a lever of the first order, and has either equal arms, like a common pair of scales, or unequal arms, like the steelyard.

“ When the centre of motion is at one end of the lever, it is a lever of the second order.

“ Remember now the following law ; *the powers acting on the lever are in equilibrio, when they are in the inverse ratio of their distances from the centre of motion.*

“ This law we find confirmed by experience in all cases, and with this we will rest satisfied for the present ; but it is capable of demonstration, without having recourse to experiment, as you will learn hereafter, when you have made farther progress in the sciences.

“ Thus, when a considerable weight lies, or is suspended near the centre of motion, it may easily be balanced or raised by a small weight, if this be at a sufficient distance from the centre. You may see this put into



practice daily by masons and carpenters, if they want to lift up a heavy stone or beam a little, so as to move it forward, or turn it over, they place a pole under it, the short end of which rests upon the ground, while they heave at the long end with their hands or shoulders."

*W.* "I have often seen them do that."

*F.* "Every workman knows, as well as you, from experience, that the nearer the weight is to the one end of the lever, and the nearer to the other end he takes hold of the pole, the easier he can lift it. In a few days I will show you a practical application of this simple instrument, the lever, which, I am sure, will excite your astonishment."

"To return to John's performance, which is easily explicable on this principle. The tobacco-pipe here is a lever of the first order. The centre of motion, or fulcrum, is the point where it touches the edge of the table. The bucket is suspended close to the fulcrum. The head of the pipe, at the end of the longer arm of the lever, serves, together with the weight of the stem, to balance the bucket."

"The chief art in the business is, to hang

the bucket close to the edge of the table; for which purpose it's handle should have a proper shape. If this be thick and round, the stem of the pipe will break; and indeed all pipes will not answer for the experiment."

William now made a little calculation concerning this experiment. He asked John how much the bucket weighed, and was told about thirty pounds, for it was not a large bucket, and John had not filled it to the brim. William then borrowed a pair of scales of his mother to weigh the tobacco-pipe, and found it to weigh two ounces and a half. The bucket was so close to the edge of the table, that he estimated the point of suspension at no more than the tenth part of an inch, or a line from the fulcrum. So far he went on rightly; but he was about to make a considerable error with regard to the weight of the pipe, by considering the whole of it as at the farther end, or in the bowl. His father informed him, however, that this weight lay in the centre of gravity of the pipe, which he might easily find by balancing the pipe horizontally on his finger. On trial, in this way, he found, that the centre

of gravity of the pipe was twenty inches distant from the edge of the table.

*F.* "Now, to find on which side the preponderance must be, you have only to find the *momentum* on each side; that is, the weight, or power, multiplied by the distance from the fulcrum; and on whichever the *momentum* comes out greater, on that the preponderance will be. I need not caution you, I presume; that both the distances and weights must be reduced to similar denominations: thus you may express the distances in lines, the weights in half ounces."

Accordingly William reckoned as follows:

|          | Bucket          |  | Tobacco-pipe  |
|----------|-----------------|--|---------------|
| Weight   | 30 pounds.      |  | 5 half ounces |
|          | 32              |  |               |
|          | <hr/>           |  |               |
|          | 60              |  |               |
|          | 90              |  |               |
|          | <hr/>           |  |               |
|          | 960 half ounces |  |               |
| Distance | 1 line.         |  | 200 lines     |
|          | <hr/>           |  | <hr/>         |
| Momentum | 960             |  | 1000          |

whence he perceived, that the bucket could not preponderate, as the greater momentum was on the side of the tobacco-pipe.

## CHAP. XVI.

## THE HEAVY GOOSE.

WILLIAM had reflected on what his father had said concerning the bucket and the tobacco-pipe, and thought he would pose John in his turn.

*W.* "John, how far do you think you can carry a goose?"

*J.* "As far as you please, Sir."

*W.* "I believe not. I can set a goose upon your shoulder, that you cannot carry the length of our garden."

*J.* "What, a leaden goose, I suppose."

*W.* "No: the fat goose you killed this morning."

"I should like to see that," replied John: for he was a stout youth, and thought his young master could not place a goose, that weighed only twenty pounds, in such a position upon his shoulder, as to prevent him from carrying it to the next town and back again, if it were required. On trial, how-



ever, John was foiled, and found himself obliged to lay down the goose.

William had taken a stick six feet in length, at one end of which he hung the goose, and the other he placed upon John's shoulder in such a manner, that the end, by which he was to hold it, was only half a foot from the point of support. In consequence, the distance of the goose from the fulcrum being eleven times that of John's hand, John was obliged to exert a power equal to eleven times the weight of the goose, or two hundred and twenty pounds, to keep it in equilibrium, and the two powers pressed upon John's shoulder with a weight of two hundred and forty pounds, which was more than he could support.

"That you may not have too high an opinion of your knowledge," said William's father, "now let me ask you a question. If you and John were to carry the goose on this stick, each holding the stick by one end; and John be as strong again as you, in what part of the stick should we place the goose, that the weight each would have to carry might be proportionate to his strength?"

William began to study, but was not soon ready with his answer.

*F.* "Would you be content, that the goose should hang in the middle of the stick?"

*W.* "No: for then we should have equal weights to carry; and, as I am the weaker, that would not be fair."

*F.* "Should it be nearer you, then; or John?"

*W.* "Nearer John."

*F.* "How much nearer?"

*W.* "A fourth part."

*F.* You say this by guess. But if John knew what he were about, he would not allow it, for thus it would be too near him. If, however, we divide the stick into three parts, and hang the goose so, that it would be four feet distant from your hand, and two feet from John's, neither would have any reason to complain.

"With respect to you, William, John's hand is the fulcrum of the lever; the distance of the weight from the fulcrum is two feet, the distance of your hand from the fulcrum is six feet, or three times as much, so that

you have only one third of the whole weight to support, or six pounds and two thirds of a pound.

“ With regard to John, your hand is the fulcrum, the distance of the weight is four feet, and the distance of the power six feet, as before. Now since the former is two thirds of the latter, he must exert a power equal to two thirds of twenty pounds, or thirteen pounds and one third, which is just double that of yours, and consequently the proportion required.”

William perceived this, and wished to know the rule for finding the proportion.

*F.* “ It is very simple. We add the two numbers, which express the relative proportions of the powers; as in this case two and one make three: we divide the lever into so many parts as the product gives, and we place the weight so that the parts of the lever on either side of it will be in the inverse ratio of the powers. Thus, in the present instance, your hand would be twice as far from the weight as John's, to which we allow twice the strength of yours.”

## CHAP. XVII.

WHAT ARE THE SMALLEST ANIMALS  
WE KNOW?

“WHY do you keep that dirty water in that glass, father?” said Caroline: “it has been there a long while; shall I throw it away?”

F. “Not yet, my dear: I will first show you something very astonishing in it.”

“Astonishing? What?” inquired Caroline, with eager curiosity.

F. “An immense multitude of living creatures, which you cannot discern with the naked eye, but which may be rendered visible by a good magnifying glass, or *microscope*. Call William, it will excite wonder in you both.”

While Caroline was gone for William, Mr. Goodwyn set his microscope in order, and screwed in a lens with a very highly magnifying power\*.

\* What microscopes and magnifying lenses are, will be explained more fully hereafter.



William and Caroline came in, and stood looking on with eager expectation.

*F.* "See this drop of liquor, which I have taken out of the glass: what do you perceive?"

*C.* "Nothing but dirty water."

*F.* "I will now place this drop on the slide under the microscope. Caroline, you look in first; then William: but you must not move the microscope."

*C.* "Bless me! it is all alive. Look, William, what a multitude of little creatures!"

*W.* "A multitude, indeed! and how fast they move about!"

Caroline and William could not enough admire this wonderful spectacle. "What creatures are they?" "Why cannot we see them with our naked eyes?" "How small they must be, for a single drop of water to contain such numbers!" "Where did they all come from?" Thus they went on with question upon question.

I doubt not, my young readers, but you would be equally astonished, and equally inquisitive, if you had an opportunity of seeing a similar exhibition; and are at least desirous

of some further information, respecting this natural curiosity. I will therefore proceed, to give some account of it, which will unquestionably amuse you.

These creatures, the smallest with which we are acquainted, are called *animalcules of infusion*. They are thus named, because they are produced in infusions, and are such diminutive animals. For their production nothing more is required, than to pour water on any animal or vegetable substance, and let this infusion stand four or five days in a moderately warm room, when a species of fermentation will take place in the liquor, a slimy skin will grow over it, and an immense multitude of these animalcules, visible only by means of the magnifying glass, will be found in the fluid. They may be obtained from different vegetable substances, as I have observed; but from some more, from others less. They are produced in the liquor of oysters; in infusions of meat, pepper, or chopped straw; and more abundantly in infusions of hay, of a sort of periwinkle, or of mignonette, an odoriferous flower, with which you are all acquainted, and many other flowers. From some flowers, indeed, I have

not succeeded in obtaining any: but it is probable, that I did not take them at a proper period. Of the numerous infusions, however, with which I have made experiments, none afforded me such multitudes of animalcula as thyme. If you put as much thyme as may be taken up between the ends of the thumb and two fingers into a wine-glass, fill the glass with pure water, and let it stand for four days, you will be truly astonished, when you look at a drop of it through the microscope. Millions of animalcules swim about in it, and the celerity of their motions is so great, that it makes the eye almost giddy. Figure 4 will give some idea of them; only you must conceive the animalcules to be infinite in number, and all in motion.

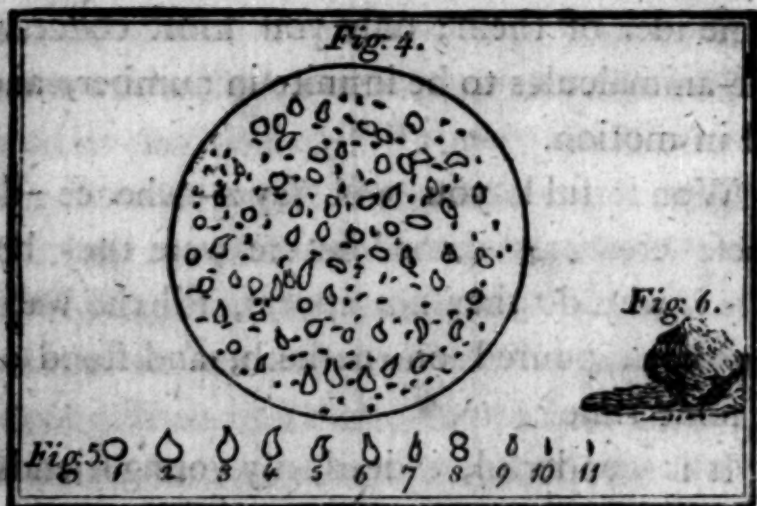
Wonderful! you will say:—whence do these creatures come? where were they before? why do they not appear, till the water has been poured on the herb, and stood on it some time?

It is wonderful, indeed, my young friends: and who is there, to whom these questions will not suggest themselves, when he discovers an ocean of animated beings in a drop of

water, where a little before nothing was to be discerned?—But who can answer them?—Instead of stopping at these questions, we will pursue our observations themselves a little farther, if you have any inclination to hear more of creatures, of which millions may be swept from the glass at one stroke with the point of the finger. Of their existence I can entertain no doubt.

## CHAP. XVIII.

### CONTINUATION.



FIRST we will consider the figure of these animalcula. Some natural philosophers as-



fert, that they have perceived a difference in their figure, according to the substances from which they were obtained. I will not contest it: though I must say, that I was never able to discern this difference, in the observations I have made on various infusions. The animalcules in the infusion of hay, for instance, appeared to my eye the same as those in the infusions of thyme and mignonette. Variety in the figures and sizes of the animalcula I have observed, it is true; but in the very same infusion, not in the infusions of different substances. One and the same animalcule, too, may assume different figures. The following are my own observations on the subject.

The usual form of the animalcules, when at rest, appears to be spherical, or a little longish, or egg-shaped, as fig. 5, Nos. 1 and 2. When they are in motion, their bodies are more or less elongated, accordingly as they swim about with more or less celerity, as Nos. 3 and 4. Some are seen darting along with great swiftness, the figure of which is nearly linear, or resembling that of a small worm.

When the animalcules have this elongated figure, as in No. 3 and 4, we may clearly distinguish one end to be pointed, and the other pyriform, that is, shaped like a pear: and it is to be observed, that they always swim with the pointed end forward, whence we may conclude, that this is the head of the animalcule. This inference is confirmed by the observation, that the animalcule can make particular movements with this pointed or foremost end, of which I shall say something more by and by.

With regard to the colour of animalcules of infusion, I have almost always seen them clear and transparent as water; properly, therefore, without any colour. Sometimes, however, a few swim through the field of the microscope, which are brownish and opaque; but these are much rarer than the transparent ones, and for the most part tolerably large.

In the thick or pear-shaped end may be discerned dark points, or curved lines variously crossing each other, which some have considered as wrinkles in the skin of the animalcule; but it is probable, that they are internal parts.

## CHAP. XIX.

## CONTINUATION.

THE size of these animalcules, I mean their apparent size, varies greatly. With a glass that magnifies the diameter of an object three hundred times\*, some appear about the size of a small bug, seen at a distance of eight inches from the eye, others the size of a louse, others still smaller, and lastly, at which I have been most astonished, as were two of my friends, who observed it with me, among these larger animalcules in the infusion of hay may be seen an infinite number of *minute animated specks* swimming about, which, with this great magnifying power, appear no bigger than the smallest mite, or

\* Magnifying powers should always be reckoned thus, that is, according to the diameter. When the diameter is magnified 300 times, the surface is magnified 300 times 300, or 90,000: but some, who are fond of immense numbers reckon by the magnifying of the solid, which in this case would be twenty-seven millions of times.



finest grain of sand, does to the naked eye, yet their voluntary motion is clearly perceptible.

Probably, too, the size of the same individuals varies, for no doubt they are at first small, and grow larger from the nutriment they take. Probably those infinitely small points, that we observed in the infusion of hay, were a numerous young brood, a new rising generation of animalcules. If we examine an infusion, of thyme for instance, on the third day, only a few animalcules will be seen; chiefly of a round figure, and neither so large nor so lively as on the fourth and following days, when they are considerably more numerous, brisk, and large. Some days after, when the infusion has dried away a little, they again appear smaller and less lively.

You will ask me, my young readers, how big the largest of these animalcules of infusion may be: accordingly I shall endeavour to give you some conception of their minuteness. A grain of very fine sand, when magnified to a certain degree, but far from the highest magnifying power, appears about the size of fig. 6. The largest animalcule of in-



fusion, with the same magnifying power, will appear at least six times less in diameter. Whence it follows, that upwards of two hundred of the largest animalcules of infusion may be contained in the space occupied by one of the smallest grains of sand. A little mite is to one of these animalcules much the same as a turkey is to a sparrow.

Reason here, you will say, is at a stand: a remark on no occasion more strictly true, than when with artificial aids we overstep the limits, to which nature has restricted our senses. What lies beyond the natural boundaries of our senses and imagination, reduces reason to a stand, as it is aptly expressed. Thus it is, when, availing ourselves of the magnifying power of the lens, we see a drop of water swarm with multitudes of living creatures; thus, when through the telescope we perceive the boundless space of the firmament filled with stars innumerable. At your age, my young friends, such a prospect excites for the most part astonishment merely: hereafter, when you have learned to consider these wonders in a higher point of view, a nobler and more exalted sensation will fill your hearts. May you become truly alive

to this sensation, and enjoy it in it's full extent.

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## CHAP. XX.

### CONTINUATION.

As you do not appear to be weary of hearing of these little invisible creatures, I shall proceed with the subject. We will now consider their motions. You can conceive nothing more lively, than these animalcules: the bustle of a nest of ants, or swarm of gnats, is sluggishness to it. They dart in all directions, like an arrow from a bow, across the field of the microscope, in straight lines, when, as I before observed, their bodies are drawn out greatly in length. Sometimes they conceal themselves under the slime of the liquor, as if they were seeking their nutriment there: then they reappear, swimming in various directions, and dexterously passing each other when they meet. Sometimes they draw their bodies up together in a spherical form, and then stretch them out again, in the same manner as a leech. Now they ap-

pear to dive down toward the bottom of the drop, as only their hinder parts are visible: presently they spin round like a top, with incredible velocity. When one of these animalcules has entangled himself in a particle of slime, it is pleasing to see how he whirls himself round with it, in order to extricate himself. It is equally pleasing to observe the motions, which they frequently make with the head, or pointed fore-end. When they give themselves a spring to dart forward, they frequently turn the head quickly on one side, as if they were biting at something, and swim forward with the head in this oblique direction, as at No. 5. One of my friends observed, that it looked as if they snapped at the little animated points I mentioned just now, and went in chase of them.

The longevity of these animalcules cannot easily be ascertained. Those that we contemplate under the microscope do not die a natural death, but are destroyed by the evaporation of the fluid, which leaves thousands of their dead bodies on the glass slide, in the shape of a little scarcely perceptible dust. It is observable, that, in an infusion, which has stood a week or more, they become smaller,



and at length seem to disappear. Whether, however, these smaller animalcules be the same, which have gradually diminished in size, or whether they be a more diminutive species, which at last alone remains, cannot be ascertained.

The numbers of these animalcules surpass all conception. Since there are so many thousands in a single drop, what multitudes must there be in a wine-glass, that apparently contains nothing but a little dirty water! what, in a puddle, or ditch, where animal and vegetable substances putrefy together! How infinite this world of organized living beings, all of which are provided with instruments of motion and nutrition!

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## CHAP. XXI.

### CONTINUATION.

It is not easy for any one, who has contemplated animalcules of infusion through a good microscope, to consider these minute bodies as any thing else but living creatures. Yet, that they are so, has been denied: and



the great celebrity of the natural historian, who will not allow them to rank among animals, may give some weight to this hypothesis; for which reason it deserves to be noticed here.

The naturalist, to whom I allude, is no other than Buffon, with whose name and repute I presume few of my readers are unacquainted.

“ We need not be apprehensive of going too great a length,” he observes, “ if we assert, that the grand division of natural productions into *animals*, *vegetables*, and *minerals*, is far from comprising all kinds of material beings.” He conjectures, that “ a closer scrutiny into nature will lead us to the discovery of certain *middle beings*; such organized bodies, as do not possess like plants and animals for example the faculty of reproducing their like, though they have a *kind* of life and motion; or bodies, that are neither animals nor plants, yet may contribute to the composition of both; or beings, that are properly nothing more than an aggregation of organic particles.” He is inclined to consider eggs as belonging to the first of these classes; “ and the moving corpuscles, ob-

served in the infusions of flesh, or seeds and other parts of vegetables, might be reckoned in the second class of these equivocal beings. They are the organic particles, or primary aggregations of them, from which the organic bodies of animals and plants are compounded.

“Still farther to confirm this opinion, that these organic bodies are not real animals,” continues Buffon, “we need only consider attentively the appearances, that the experiments exhibit. Men have supposed these corpuscles to be animals, because they display a progressive motion, and the observers have persuaded themselves, that they have seen tails to them\*.

“May we not very reasonably doubt these suppositions,” he adds, “when we consider, on the one hand, the sudden and total discontinuance of the progressive motion begun, and on the other the reality of the supposed

\* In all the animalcules of infusion, that I have seen, I have never discerned any thing like a tail: it is possible, however, that there may be such an appearance in some, as observers, whose accuracy and fidelity we have no reason to dispute, mention it.

tails, which are nothing more than filaments, that the moving bodies draw after them \* ?

“ An animal moves now quickly, then slowly, and sometimes rests from motion.

“ These corpuscles, on the contrary, continue moving on in the same manner, without ever reposing, and then renewing their movement. They continue to proceed onward without stopping; and when they have once stopped, they remain immoveable. Such a perpetual motion, uninterrupted by repose, can by no means be considered as the ordinary motion of an animal.”

We might here be inclined to doubt, whether Buffon ever saw any animalcules of infusion, if it were not for the many experiments he relates with much prolixity. At the first view through the microscope we may see, that the animalcules move sometimes faster, at other times slower, now here, now there, rest from motion, and then move again, turn round on their own axis, &c. It is incon-

\* The trace left behind in the water by the animalcule moving with such velocity may give the appearance of a tail.



ceivable to me, how Buffon could pen such a palpable untruth.

“ Besides,” he goes on, “ let us conceive what animal we will, it must have some permanent form, and distinct limbs: but it is well known, that these moving corpuscles are changing their figure every instant, have not one distinct limb, and their tail appears to be a mere accidental circumstance.”

At the commencement of this passage the reader will immediately think of the leech, which, when it swims in the water, has a long extended figure, yet at times draws itself up into a very different shape. Exactly the same change of form may be observed in the animalcules of infusion, which always return to their common oval figure. Their change of form, too, is frequently in appearance alone, arising from their different position with respect to the observer's eye. The assertion, that they have no distinct limb, is confuted by the remark made above, that they move their heads, and turn them on one side.

From what I have here subjoined to the assertions of Buffon, I apprehend, it will sufficiently appear, how little foundation

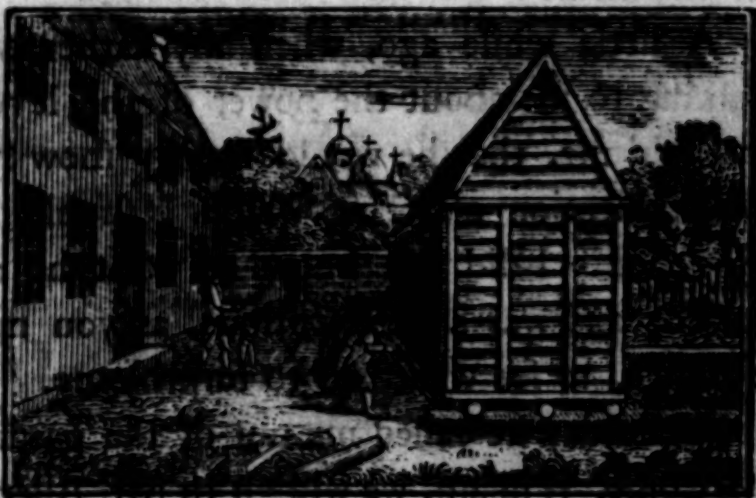


there is for the hypothesis, that denies animalcules of infusion the possession of proper animal life and perception. This may serve as a caution to you, my young readers, that we must not always rely implicitly on the assertions of a man of great name.

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## CHAP. XXII.

### THE HOUSE REMOVED.



DEAR HENRY,

WHEN you come to see us again, you will find great alterations. A house has been built on what was a vacant space: instead of an old building, that appeared tumbling

down, a large new one has been erected: and last of all, a whole house has been removed to some distance from the place where it stood.

“Removed to some distance,” you will say: “yes, pulled down, and built up again in another place.”

No, Henry; actually removed to another place in the proper sense of the words. I myself saw it done yesterday, and my head is so full of it, that I must tell you the whole of the affair.

A little while ago, when my father was talking to me about the power of the lever, he told me, that he would shortly show me an application of it, at which I should be surprised. I did not know to what he alluded, and was a little curious, as you may suppose, to see what was to surprise me.

Yesterday he called me out of the garden. “Come, William, we will go to Mr. Allen’s, and see a house pushed out of the way.”

I almost thought my father was in jest, but he looked seriously, and he is not apt to jest with me.

Accordingly we went, and presently we saw the business commence.

I know, my dear Henry, that you are older, and bigger, and know more than I; and will understand the business better yourself, than I can describe it: but it is for my own profit and satisfaction, that I give you a description of it; not to instruct you, which your tutor can do better.

The building, that was to be removed, was neither one of the pyramids of Egypt, nor St. Paul's church, as you may suppose; but it consisted of a two-stall stable and coach-house, the brick, and wood, and tiles of which, must be of some weight; and which stood so near Mr. Allen's house, as to render his yard very small. He would have pulled it down, and built it up again farther off: but an ingenious carpenter told him, that he would engage to remove it as it was.

You must not be angry with me, Henry, if I seem a little tedious in telling my story. I believe the carpenter would take less time to remove a house with his levers, than I do to give an account of it.

First a trench was dug in the ground, so as to admit large beams to be placed under the frame timbers of the building, notches being first cut in the beams, to admit the

timbers. Under these beams several wooden rollers were placed: and these rollers rested upon long balks, which they called ways, and which reached as far as the building was to go.

Once, my father told me, a church-steeple, with the bells and every thing in it, was removed some yards in this way, men chiming upon the bells at the same time.

The preparations, that I have been describing, were made before we came: the work itself was now performed, and took up no long while.

About a dozen men were stationed with strong levers in their hands, which they passed under the frame-timbers, the ends resting against the ground. The carpenter gave the words of command: "one, two, three." At the word three, all at once bore against the end of their lever with the shoulder, by which the frame-timbers, and consequently the whole building, were moved forward upon the rollers a few inches. They then halted, the carpenter examined whether the building had moved in a straight direction, and whether the beams lay properly on the ways: the rollers were moved, as it was



found necessary: the word of command was given again; and the building moved forward a few inches more. In this manner they proceeded, alternately applying the levers, and observing the progress of the building, till the stable and coach house arrived gradually at their destined place, without having suffered the least injury.

Thus you have my story, my dear Henry; which, I hope, will not be unwelcome to you: though I could have wished you had been present, for we cannot see houses moved about every day. Adieu! Think of us often, and particularly of thy affectionate,

WM. GOODWYN.

## CHAP. XXIII.

## THE SEE-SAW.



*Father.* "You are warm, William: what exercise have you been taking?"

*William.* "Charles and I have been swinging, and playing at see-saw."

*F.* "Very good. I am always glad to hear of your exercising yourself: now is the proper time for it, while all your joints are supple. Run, jump, dance, swing, play at see-saw, walk upon a round pole: all these exercises promote corporal agility, which is of advantage to us on numberless occasions,

strengthen the body, preserve health, and impart cheerfulness to the mind. But, in the first place, be prudent in all your exercises, and not rash: secondly, never bestow more time on them, than your other occupations will allow. Neglect not the improvement of your body; yet pursue it in such a way, that it may tend at the same time, to promote the improvement of your mind, instead of being injurious to it. Mental and corporal exercise should be employed alternately to relieve each other: suppose we try, therefore, whether we cannot find some employment for the mind in a consideration of the bodily exercises, with which you have just been amusing yourself.

“For example, you are bigger and heavier than Charles; cannot you tell me, from the law of equilibrium with the lever, which I lately explained to you, how the board should be placed upon its support? Suppose yourself to weigh fifty-five pounds, Charles only forty-five, and the board to be ten feet long.

“The weights are both divisible by five, and, when divided by five, are to each other as eleven to nine. According to the

rule you gave me, I must add these two numbers together, divide the board into twenty parts, and set off nine of these, that is four feet and a half, on my side, or eleven, that is five feet and a half, on Charles's to find the point on which the board should rest. The moments will then be equal, as 9 times 55 make 495, and 11 times 45 make just the same; so that the board, when we stand upon the ends of it, will be in equilibrium."

F. "You have not forgotten the rule, I find; but I have another question to ask you. When you are standing on the ends of the board, and the board is at rest, how do you make it move up and down?"

William knew better how to do this, than how to describe it. "See, father," bending his knees, and straightening them alternately, "we do so."

F. "I know it, but how does this motion act upon the board, so as to make it move up and down?"

This William could not tell.

F. "It is clear, that, if the board be at rest in a horizontal position, and you stand still upon it, it will not move of itself.



When, after having bent your knees, you stretch them out again, the board is impelled downward. If you stood on the ground, and made this motion, the consequence would merely be, that your body would be raised up by it, for the ground would not give way; but as the end of the board is moveable, the stretching out of your legs will act both upward and downward at the same time, so that the force you exert will be spent partly in raising your body, partly in depressing the end of the board. The boy at the other end of the board makes the same motion, and thus gives the board a similar impulse, alternately with you : whence the two ends of the board must move up and down alternately. as long as you continue thus to keep it in motion.

“ Do you understand me ? ”

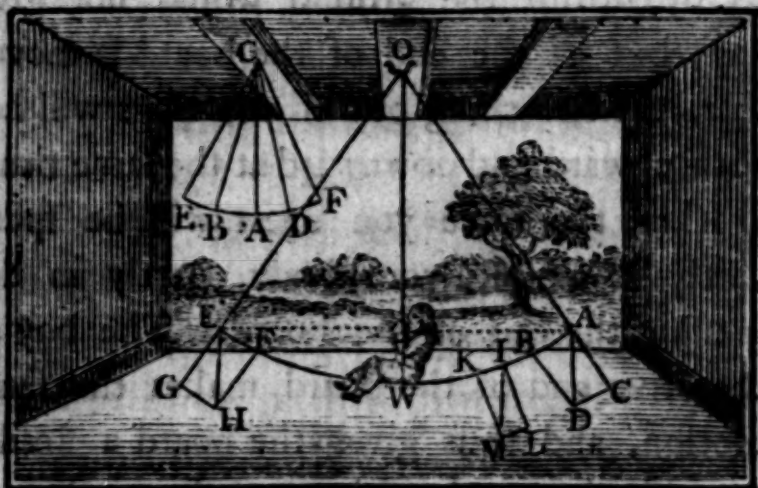
*W.* “ O, very plainly.

*F.* “ Thus in the most common children’s plays, as in see-saw, you see there is food for the mind.

“ Now then to the swing.”

## CHAP. XXIV.

## THE SWING.



*William.* "O, that is a rope fastened at both ends to a beam, I seat myself upon it, Charles stands behind me, gives me a push, and so it goes on, forward and backward."

*Father.* "Your 'O,' which, by the by, I cannot commend as an exordium, seems to imply, that there is nothing remarkable in the case; but let me ask you, why does it go on, as you say, backward and forward? Or rather, why does it not continue to go on? for, if Charles did not repeat his pushing every now and then, the vibration of the swing would soon cease."

And, lastly, how can a person swing himself, without receiving any push from another?"

William appeared to be puzzled by these questions, and looked as if he felt, that he had been a little inconsiderate at the outset.

*F.* "We will suppose  $OW$ , in the drawing I have made, to represent the swing, made fast to the beam above in  $O$ . If Charles pulls you backward, this must be in a segment of a circle, say  $WA$ ; and when he has pulled you backward to  $A$ , the swing will be in the position  $OA$ . When you are at  $A$ , your body will gravitate perpendicularly downward. This power of gravitation we will express by  $AD$ , and resolve into two others,  $AC$ , in the direction of the rope, and  $AB$ , at right angles with it. What now do you perceive in these?"

*W.* "The power  $AC$  will be destroyed by the resistance of the rope: the power  $AB$  will set it in motion."

*F.* "Right; for the latter acts in the direction the segment of the circle has at this place. Accordingly, if you were not to be pushed forward, the power of gravitation would set you in motion, and this relative gravity,  $AB$ , would be to the actual, or

that exerted in falling freely, as A B to A D, by the principles of the inclined plane.

"But will the power A B be the same quantity in every part of the circle from A to W?"

W. "I think not. It will grow less and less."

F. "Certainly. For when you have arrived at I, if we take the absolute gravity I M equal to A D, I K must represent the relative gravity, which will be obviously less than A B. And when you have reached W, where the rope hangs perpendicularly, what will the relative gravity be?"

W. "It must be nothing: for the absolute gravity will be completely destroyed by the resistance of the rope."

F. "So then no power remains to propel the rope farther?"

W. "No: for it has entirely vanished at W."

F. "What, then, will the motion suddenly stop, and the swing remain at rest in the position O W?"

W. "No; that cannot be: for I know by experience it will go a great deal farther



the other way, and then come back again; but I do not know why."

*F.* "When your body has reached *W*, must it not have acquired a certain velocity from the preceding motion?"

*W.* "I did not think of that, but I understand it now. Though the power of gravitation cannot act upon it any longer at *W*, yet it will continue in motion from the velocity it has acquired in passing from *A* to *W*."

*F.* "And how shall we determine this acquired velocity?"

"You say nothing: well, I will tell you: We must consider this segment of a circle as an inclined plane, for it is the same thing, whether the body be confined to this path by an inclined plane down which it rolls, or by a rope to which it is suspended; and we may conceive this segment of a circle as consisting of an infinite number of short planes with decreasing inclinations."

*W.* "Then the velocity, which the body has at *W*, will be exactly equal to what it would have acquired in falling perpendicularly as far as *W* is below the line *A E*."

*F.* "Consequently the body will proceed with this velocity in the same curve from *W* toward *E*. But now the power of gravitation acts counter to it's motion; and this the more, in proportion as it's distance from *W* is increased. What follows from this?"

*W.* "The body will continue losing more and more of it's velocity."

*F.* "Till it is entirely annihilated; which will be when it has arrived at *E*, through the curve *W E*, which is equal to *A W*, through which it descended. For, you will observe, the action of gravitation will be precisely equal in both curves, but in opposite directions; so that the velocity, which was acquired in the curve *A W*, will be again lost in the curve *W E*, which is exactly equal to it."

"What is the law that we have now discovered?"

*W.* "Bodies ascend in curves equal to those, through which they have descended."

*F.* "But is not the body at *E* in the same situation as it was in before at *A*?"

*W.* "Precisely."

*F.* "What follows from this?"

*W.* "It will swing back again from E to A."

*F.* "And then again from A to E, and so on. Now you know why it continues to go on backward and forward, do you not?"

*W.* (With a smile.) "I believe I do: and perhaps I could now answer the second question, why the motion ceases, if a fresh impulse be not given to the rope every now and then. The cause of this, I suppose, is the resistance of the air."

*F.* "Your supposition is not amiss; for this must continually operate to retard the motion, and is sufficient of itself to put a stop to it gradually. But beside this, the friction of the rope against the beam, and it's not yielding perfectly to the motion at the top, where it must bend a little in swinging, contribute something to retard the movement.

"My third question, how a person can swing himself, we will consider another time. At present let me ask you, are the vibrations quicker when the rope is longer, or when it is shorter?"

William knew from experience, that with a long rope the vibrations were slower than with a short one.

*F.* "If, then, we would have a rope swing with double the velocity of another rope, how much shorter must it be?"

*W.* "As short again."

*F.* "No, no, William; that would not do: it must be four times as short. You shall see it proved by experiment: at present I cannot give you a general demonstration of the problem."

"See here is a leaden ball, suspended by a slender line, three feet long, which I will set in motion. Take my stop-watch, and observe how much time it takes to vibrate backwards and forwards: you will find it is just one second in vibrating either way. This, therefore, is a second pendulum."

"Here is another pendulum, only a fourth part so long, or nine inches. Compare their vibrations, and you will find, that this makes exactly two, while the former is making one."

"This little pendulum, which is only four inches long, you will find, makes three vibrations, while that of three feet, which is nine times as long, makes one."

"Now, I suppose, you yourself can tell the law according to which these act."



*W.* "The lengths of the pendulums are as the squares of the times in which they vibrate."

*F.* "Exactly. Of this I shall some time or other give you a demonstration.

"Pendulums are of great use in common life; chiefly for regulating the motions of clocks, and rendering them uniform. To this purpose they were first applied by Christopher Huygens, in the year 1657."

*W.* "I have long had it in my mind, father, to ask you to show me how clocks are made."

*F.* "With a great deal of pleasure, William: and I will take some early opportunity of doing it; for I am glad to find, that this ingenious and useful machine has engaged your attention."

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## CHAP XXV.

### SOMETHING NEW ON THE SUBJECT OF SPIDERS.

"THESE filthy spiders" said Caroline, sweeping down some cobwebs with a brush,

"are spinning their webs in every corner, if we be not continually destroying them."

"You do not like to have them in the house, Caroline," said her father: "and, it must be owned, cobwebs are not very consistent with domestic cleanliness. Yet, would you suppose it, there are people, who take a pleasure in having a number of spiders about them."

C. "How can any person delight in such ugly creatures!"

F. "Nay, at the loss of a spider a man has felt so much, as to endeavour to put an end to his own existence; and what is more, a spider has decided the fate of thousands of men, and of whole countries."

C. "If any other person told me so—"

F. "You would not believe him. If, however, my children, you have any wish to hear something both important and amusing respecting these ugly, filthy creatures, as you, Caroline, and many others call them, I will relate to you some facts, at which you will not be a little surprised."

"O tell us all about them!" exclaimed both William and Caroline together, "we like to hear such things."

*F.* "A nobleman in France, I think it was a count of Lauzun, was condemned to a rigid imprisonment. Cut off from all human society, and allowed no means of diverting his solitude, he made a companion of a spider, who had spun her web in a corner of his cell. He at length familiarized her so far, that she would come upon his hand, and eat from it a portion of his food, which he gave her. The jailor, totally devoid of feeling, thought this too great an indulgence for the unfortunate prisoner, and crushed the spider to death. The count, thus bereft of all occupation, and deprived of the only living being about him, in a fit of despair dashed his head against the wall, and would have beaten out his brains, had he not been prevented."

"Poor man! Execrable jailor!" exclaimed Caroline and William.

*F.* "I will now relate to you another anecdote of a prisoner, more recent, but less tragical. In the year 1787, when the Prussian army entered Holland, under the Duke of Brunswick, Quatremere Disjonval, an adjutant-general in the dutch service, who had taken part against the stadtholder in the



commotions in the United Provinces, was thrown into prison. Here he remained till 1795, when he was released, on the arrival of general Pichegru, at the head of a french army. During the seven years of his confinement, he had nothing to amuse him but the spiders in his prison, which he had tamed. He had gathered about him a great number of these, of different species, and the observations he made on their manners and habits of life alleviated the irksomeness of his solitary hours. His observations on this subject he has arranged in order, and published in a little book, with the title of *Araneology*. These observations are in part new, and among other things confute the charge made against spiders, that they devour one another. It is true, they do this sometimes, but it is only when they can procure no other food, and are driven to it by necessity. Thus Reaumur, a celebrated french naturalist, collected together a great number of spiders, in order to try whether their webs might not be applied to the purpose of manufactures, as well as those of the silk-worm. The spiders were so numerous, however, that they could not find a sufficient number of flies and other



insects for their food, so that in a short time they were obliged to feed upon one another, and thus the hope of obtaining profit from their labours was frustrated. It is a fact, notwithstanding, that stockings of great fineness and warmth, and of considerable strength, have been fabricated from cobwebs.

“ The most remarkable observation of our prisoner, Mr. Disjonval, was, that spiders are particularly excellent as prognosticators of changes in the weather, being more certain than the barometer, giving their indications a longer time beforehand, and having this advantage to the lower class of people, that they cost nothing.

“ On the common house-spider, for example, he has made the following remarks. Against fine weather, it peeps out it's head, and stretches it's legs out of it's hole, and this the farther, the longer the fine weather will continue. Against bad weather it retires farther back: and against very tempestuous weather it turns quite round, showing nothing but it's hinder parts to the observer, thus acquainting him with the approaching change of the weather. At the commencement of fine weather, the web, with which

it surrounds it's corner, is but of moderate extent: if the fine weather will be lasting, it enlarges it two or three inches; and if it do this several times repeated, we may be certain, that the weather will continue fine for some time.

“ On the 22d of july, 1795, Mr. Disjonval foretold, from the behaviour of his spiders, a fortnight beforehand, that the water of the Rhine would fall so, as to render it passable by a bridge of boats; and in this manner it was actually passed.

“ In winter they are as certain prognosticators of approaching cold. If frost and snow be coming on, they either seize upon webs already made, in which case obstinate battles frequently ensue, or they make new ones, and labour diligently at them. Disjonval found, from several attentive observations, that, from the first of the spiders putting themselves in motion to the setting in of the frost, nine days generally elapsed. We have a striking instance of the justice of this observation in the beginning of February 1793. The weather was fine, warm, and there was no symptom of approaching frost. It might have been supposed, that fires would

be no longer required: but on the 4th of february, Mr. Disjonval announced, that a great alteration in the weather would soon ensue, as, beside other remarks of a similar kind, he had seen three spider's webs, one over another, in a place where there was not one the preceding evening. On the 9th of february there was ice, and by the 13th all the canals were frozen over. It was now probable, that with the breaking up of this frost the winter would terminate. This was the opinion of Mr. Disjonval himself: and he felt no small satisfaction, in having been able to foretel the freezing of the canals to a whole town, when such a circumstance was least expected. A complete thaw in fact came on; but on a sudden he observed, contrary to all expectation, a general bustle among his spiders on the last day of february. They ran backwards and forwards, began to spin webs diligently, and attacked one another. Hence he inferred, that some remarkable change was taking place; and that very dry weather at least, if not very cold, would ensue. This conjecture he announced to the principal bookfeller in the town, and through him to the public. Two



days after it rained, which seemed no way favourable to his prognostication; and this rain continued for five days, so that the validity of his prediction appeared daily more questionable. Still, however, attentive to the proceedings of his spiders, he wrote every day to the same bookseller, telling him he continued firm in the persuasion of the approach of cold or dry weather. On the 8th of march it blew hard; on the 9th it snowed; and on the 10th the frost was so sharp, that all the canals were frozen over again.

“ The greatest and most striking instance of the importance of these observations, and the dependance that may be placed on predictions respecting the weather from them, is the conquest of Holland by the french in the winter of 1794-5. Disjonval's keeper was inclined to the patriotic party, and in consequence treated his prisoner with less strictness. Through his means Disjonval gave notice to the patriots, that a hard winter would ensue, which would render all the rivers and canals passable on the ice. The taking of the town by the french afforded him the only hope of being emancipated from his long imprisonment: it may



be supposed, therefore, that he observed his spiders with the utmost care and attention. In the beginning of december he heard, to his great alarm, that the people talked of a capitulation, which would have annihilated his hopes at once. He used every means in his power, to make known, that, from the operations of his spiders, a very severe frost would inevitably come on, and this within a fortnight at farthest. The people gave credit to his prediction; did not capitulate, and on the 29th of december the frost was so hard, that the french were able to pass the Waal. The aristocratic party flattered themselves, notwithstanding, that the frost would soon break up, as on the 12th of january the water rose, and was turbid, which was considered as a certain indication of a thaw. Disjonval, in the mean time, wrote from his prison to the editor of the Utrecht gazette, that, before three days had elapsed, a more severe cold than the former would take place. On this occasion the spiders proved incomparably better prophets than the turbid water; on the 14th of january the wind rose, on the 15th it froze, and on the 16th the french

entered Utrecht; thus the prisoner regained his liberty.

"He continued carefully to observe the spiders he could find, in order to give the french general fresh information, which was of such importance to him in this daring enterprise. On the 20th of january a sudden thaw came on. The general was alarmed for the fate of an army of a hundred thousand men, with a train of artillery, and began to think of a speedy retreat. But Disjonval had recourse to his spiders, and they foretold frost. He sent a couple of these little prophets to the french general: they were credited, their prophecies were fulfilled, and the french conquered Holland.

"Such a striking circumstance induced the french executive directory to institute an inquiry into this new branch of knowledge; observations will be made, most probably, in other countries; and thus these *odious* spiders may be found of great importance in meteorology, and consequently of great use in common life."

## CHAP. XXVI.

## THE TREE FROG.

WHILE we are on the subject of prognosticators of the weather, it may not be amiss to mention two other animals, which possess this remarkable and useful faculty of foretelling changes in the atmosphere, by their actions, with tolerable accuracy. One of these is the dog. When dogs eat grass, we commonly infer, that rainy and stormy weather will come on. But the tree frog, or green frog, is much more distinguishable for this faculty; on account of which it is kept in glasses, in many parts of Germany, as we keep gold-fish, and fed with live flies. Of this frog I will give you some account.

The tree-frog is distinguishable from other species by it's form, voice, and mode of living. It is of a small size, grass-green colour, and has four little round warts, or knobs, on the fore-feet, and five on the hind-feet. The hind-feet only are webbed, and not more than half-way up the toes; yet, which is remarkable, it swims



faster than most other frogs. The skin under the throat is pendulous, or hangs loose; but more so in the male than in the female. By means of the warts on the toes it can adhere to the sides of the glass, or other smooth surfaces; and in this it is assisted by the skin of the throat, which likewise it sticks, as it were, to the glass. This adhesion to a smooth perpendicular surface may be owing to two causes. The whole body is covered with a kind of slime, and a glutinous moisture exudes from the warts, by means of which it may stick to the glass by cohesion. The *pressure of the air* is probably another cause: for, that this cohesion alone is not the cause, that enables the frog to stick to the glass, is evident from the circumstance, that the frog cannot stick to the sides of the receiver of an air-pump, when the air in it is rarefied, but always falls down. Hence it appears, that the warts on the feet act as those suckers, with which boys lift up stones. With one of these warts singly the frog can fix itself to the cover of the glass, so that it's whole body hangs suspended from it.

The voice of the tree frog has very little resemblance to the croaking of other species.



It consists in a continued creak, much like the rubbing of a blunt file against a piece of steel, or the back of a knife against an earthen plate. You may deceive the tree frog in this manner, particularly in the evening, so that it will answer you with it's voice, when it hears this noise. It is only the male, however, that emits this sound, and not before he is three years old. To make this cry, he swells up the skin of his throat like a thick round bladder, the sides of which shrink in, while he forcibly expresses the air from it. It is commonly in the evening after sunset, and in the morning at day-break, that this cry is heard.

These frogs inhabit most parts of Europe, though we have never heard of one found in England. When they are at liberty, they abide in the water during the spring; but in summer they live mostly on the land, climbing up trees, and feeding upon insects. In winter they bury themselves under ground, and remain torpid as long as the cold weather continues. In a glass, however, in a warm parlour, the tree frog will remain for weeks fixed to one spot, and can live two or three months without food. If a live fly be thrown

into the glass, the frog catches it with a leap, which is so well aimed, that it fixes itself to the glass at the same time with all four feet. A dead fly it will not touch: and it never leaps after a fly, that remains without moving, but sits still, watching it with fixed and staring eyes. The moment the fly begins to move, the frog springs on it with extraordinary agility and certainty, and snaps it up, using for this it's thick rough tongue, rather than it's lips. It eats spiders, and other insects, likewise; and may be deceived with other things, that look somewhat like insects, if they be set in motion. Thus if a piece of a prune be fastened to a horse-hair, and moved a little, so as to have an appearance of being alive, the frog will leap at it; which it would not, if the bit of prune were laid down, or held still.

The remarkable sensibility of this animal to changes in the weather renders it a kind of barometer, and we may frequently find it's intimations deserve more confidence, than those of the rising or falling quicksilver. When the tree frog dives into the water at the bottom of the glass, we may be pretty certain, that it will rain soon. If it remain

long in the water, the rain will continue some time. During the continuance of the wet weather, it will abide principally in the water, and be tempted to leap out of it only by a fly, or some other prey. If the weather be very bad, the frog will be restless, or lie stretched out as if dead on the bottom of the glass, or appear convulsed. On the other hand we may expect fine weather, when the frog attaches itself firmly to the glass above the surface of the water, or climbs up a little ladder, that is placed in the glass. The cry of the male, too, denotes dry and settled weather.

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## CHAP. XXVII.

### OF THE RATTLESNAKE.

MOST of my readers, I presume, have heard of the rattlesnake, of which so many wonderful things have been told. It certainly deserves notice: and it is also proper, that the fabulous accounts given of it should no longer be allowed to pass current. In all things truth should be our aim, and we

should never overstep its limits on any account. Is it not absurd, to recur to fable for the marvellous, when there is so much to excite our wonder and admiration in the plain facts, that nature exhibits to our observation?

This terrible animal is an inhabitant of America, and frequents woods and morasses. There are different species of it; some blackish, others of a reddish yellow colour, others of a yellow red, and brown, streaked with black lines. They differ in size likewise; the largest growing to the length of eight feet, and the thickness of a man's arm. This genus of snakes is distinguished from all others by the rattle at the end of the tail; which is of a brownish colour, consists of several horny joints, moveable on each other; and makes a rattling noise when the snake moves, whence it derives its name.

The bite of the rattlesnake is extremely fatal, on account of the strong poison which it infils into the wound it makes. This poison is contained in a small bladder beneath each of the fangs of the upper jaw, and is collected there in the largest quantity, when the animal is irritated. The fangs are



hollow, and have a small aperture, through which the poison passes into the wound. This poison kills the largest beasts, as a horse, or an ox, almost instantaneously. If a man have the misfortune to be bitten by one of these snakes, he has little chance for recovery, if the wound be not presently cauterised with a hot iron, or some caustic applied to it, which is still preferable. The negroes make use of the cautery for the purpose. There is nothing appears externally in the part bitten, except a couple of little holes like flea-bites, into which the fangs have penetrated. But a swelling soon comes on in the part, and spreads incessantly, till it occupies the whole of the limb, and at length extends over all the body, the tongue growing so thick, that the passage of the throat is stopped up. Immediately after the bite the person feels an uneasiness, which gradually increases, till at length a mortal anxiety comes on, with burning thirst, and terminates in a lamentable death, if timely recourse be not had to the proper remedies.

The poison of the snake, however, is confined to the two fangs, there being no viru-

lence in any other part of the body. The flesh is nutritious, and well-flavoured, and is eaten by the Indians without injury. To obtain it they approach the animal behind, and strike it dead.

The rattlesnake is particularly noted for the manner in which it takes it's prey. Much that is erroneous has been said upon this subject, and a power of fascination has been ascribed to the animal. That it's prey very frequently acts as if fascinated, is true ; but this arises from another cause. The rattlesnake does not climb up trees, but frequently searches among the low bushes for young birds. When the mother-bird finds her nestlings in danger, her affection for her young prompts her to their defence, she flutters about the snake, attacks it with her beak and claws, retreats a little from the danger, and almost instantly returns to the attack. Sometimes she is successful, but often she becomes the victim of her maternal heroism, and the spectator, who has seen her apparently fly into the mouth of the serpent, ascribes it to fascination. Some of you may have read this very circumstance described by Homer, who was a very

accurate observer of nature, above 2000 years ago, in the second book of his *Iliad*, l. 310.

It is not improbable, too, that the effluvia of the animal may have a stupifying effect on some animals, at least within a certain distance: for we are told by Dr. Michaelis, a physician at New-York, that once, while he was making a course of experiments on the poison of the rattlesnake, he felt himself stupefied by the effluvia of one, as if he had been in a state of intoxication, so that he threw himself on his bed, and was half an hour before he completely came to himself again.

There are instances related, likewise, the truth of which we have no reason to question, of persons, who, on seeing rattlesnakes, have been fixed to the spot, so that they could not run away. This, however, must be ascribed to the power of imagination. A man, into whose mind this belief of their power of fascination had been instilled, suddenly perceives a rattlesnake near, with his eyes fixed upon him. Is it wonderful, that his unfortunate prejudice, and the fright with which he is consequently seized, should



prevent him from making any attempt to escape, when he firmly imagines, the attempt would be vain? Such a man has been saved by his companion, whose imagination was less powerfully impressed by the idea; and made to feel, that nothing was wanting to enable him to flee, but the exertion of his will. In all situations of danger, men who consider themselves as lost, either make no attempt to escape, or know not how to effect it. This is what we call want of presence of mind: a valuable quality, the advantages of which, as well as the mischiefs arising from false impressions, are obvious in the instance just given, and in numberless occurrences of common life.

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## CHAP. XXVIII.

### SINGULAR ACCOUNTS RESPECTING TOADS.

To go on with these *odious* creatures, as too many inconsiderately call them, we shall pass from spiders, frogs, and snakes to the toad.

Toads are held in abhorrence by several persons; and some are so much afraid of



them, that the sight of one is sufficient to make them run away, or even faint. Very few, indeed, have courage to handle them. It must be owned, their appearance is not very engaging; they are soft, slimy, and filthy, to the touch; they live in wet, low, marshy, dirty places; have a slow, crawling motion; and from these circumstances probably they are commonly reputed venomous.

I confess myself, I like the lively flitting redbreast better than the crawling, dusky green toad; yet this animal is unquestionably innocent of the poisonous qualities ascribed to it, as many have proved by repeated experiment. It has no fangs, to instil venom by it's bite: the glutinous juice, that exudes from the warts or pimples on it's skin, is not poisonous, for toads have been repeatedly handled without injury, and quacks have exhibited the disgusting trick of squeezing their juices into a glass, and drinking them with impunity; and in the same manner it has been proved, that it's urine is equally innocuous. The moisture it preserves in a particular bladder has been supposed by some to be poison; but Mr. Townson, who

has very accurately examined these animals, has found it to be nothing but clear water.

The toad is capable of being domesticated, and rendered very tame and familiar. A gentleman was accustomed to feed a toad regularly for fix and thirty years, and every evening, as soon as the toad saw the candle lighted, it would come to the table, in order to be lifted up on it for it's supper, consisting of the maggots of the flesh-fly, which were it's favourite food, and various kinds of insects. These it would follow, and when within a proper distance, would fix it's eye, and remain motionless for near a quarter of a minute, as if preparing for the stroke, which was an instantaneous darting it's tongue to some distance upon the insect, which stuck to the tip by a glutinous matter. This motion of the tongue is quicker than the eye can follow. The toad here mentioned was called the old toad by this gentleman's father, when the gentleman first knew it, and at last it's death was occasioned by an accident, so that it must be a pretty long-lived animal.

Indeed what is most remarkable in the toad is it's tenacity of life. Live toads have been found more than once enclosed in solid stone, or wood, which must have grown round them, and in which they must necessarily have been confined many years. The following are a few instances of this kind.

A large block of stone was separated from a quarry in Sweden, and as one of the workmen was hewing it into shape, he found within it a living toad. It's back was dusky, and a little spotted, it's belly of a somewhat lighter colour, and the whole body was in a manner incrustated with little fragments of stone. The eyes were small, round, yellow, and covered with a tender transparent skin. The aperture of the mouth, too, was closed by a yellowish skin; but beneath this, in each jaw, were found two sharp teeth. It made scarcely any motion, except that it closed it's eyes when pressed gently on the head with a stick. On being pressed hard on the back, it emitted some cold water, and presently after died. The men attempted to cut out the piece of stone, in which the

figure of the toad was impressed, but it crumbled to sand.

In the year 1764, a live toad was found in a quarry in Lorrain, fifteen yards below the surface of the earth; and the quarrymen affirmed, that it was the sixth found there, enclosed in the stone, within the period of thirty years.

In the year 1771, a wall was pulled down in France, which was known to have stood above a hundred years. Enclosed in the masonry a toad was found, not alive it is true, but to all appearance very lately dead.

In 1719 a toad was found in the root of an elm, which was as thick as a man's body. The hole it occupied was exactly the size of the toad, and when the wood was cleft it crawled out. On examination, no chink or aperture could be discovered, through which it had entered.

In 1731 a similar circumstance occurred in an oak of still larger size.

In 1780 a live toad was found in the trunk of a large oak, fifteen feet from the root, so grown in as to be completely surrounded with solid timber. It was struck by the axe in hewing the wood, yet still moved,



and appeared to be very old and feeble. The timber round it was perfectly sound, without any hole or chink.

These instances occurred in France; the following more recent was in Germany.

On the 26th of december, 1795, as some quarrymen were cutting a very large stone into smaller blocks, they found in it three live toads, two large and one small, in an oblong hole, varnished over internally with a yellowish-brown matter. No other hole was perceptible in this stone: there was no appearance of any communication between this cell and the external air: and the stone near it was equally hard as in other parts. They were not willing to quit this hole, in which it is impossible to say how long they might have resided; and when they were driven out, they leaped in again. At length, being forced upon the neighbouring grass, they hopped about briskly, and were not easily kept together; but in the course of half an hour they all died.

Instances of living toads included in solid stone have occurred in different parts of England likewise.

From the instances related above to have happened in France, Mr. Herissant, a french naturalist, was induced to make the following experiments.

On the 21st of february, 1771, he took three live toads, and enclosed them in a deal box filled with plaster of Paris, each in a separate hole, the plaster of Paris being powdered and wetted, and covering them on all sides to some thickness. On the 8th of april, 1774, which was more than three years afterwards, he opened the box. The middle one, which was the largest, he found dead, perhaps because it was too tightly jammed in: the other two were alive and well.

In what manner can these singular facts be explained? How the toads in the cases mentioned above got into the stone, or wood, how long they lived there, and on what they lived, are questions not easy to be solved.

With regard to the first, it seems scarcely susceptible of any other answer, but that the egg must have fallen accidentally into the matter, that composed the stone, while this was still soft; or into the tree, as it began to

sprout form the feed. Form this egg the animal was gradually developed, and grew, while the substance that surrounded it yielded to it's extension.

In the stone, indeed, it might be supposed, that the animal had attained it's full growth, when it was first enveloped by the soft matter, that afterwards hardened into stone; but in the cases of trees this supposition seems inadmissible.

As to the second question; how long have these toads remained in their holes? we can only say, from the time when the stone was a soft mass, and the tree first began to grow. But when we reflect on the length of time an oak takes in growing up to a large tree, the age of the animal must astonish us. It seems scarcely credible, that an animal should remain motionless for a hundred years or upwards, during which it could neither employ it's feet in walking, it's mouth in eating, nor it's eyes in seeing; yet there is little reason to doubt, that this must have been the case. It is surprising too, that an animal, which had continued so long without moving, should have the capacity of using it's feet, and know how to use them.

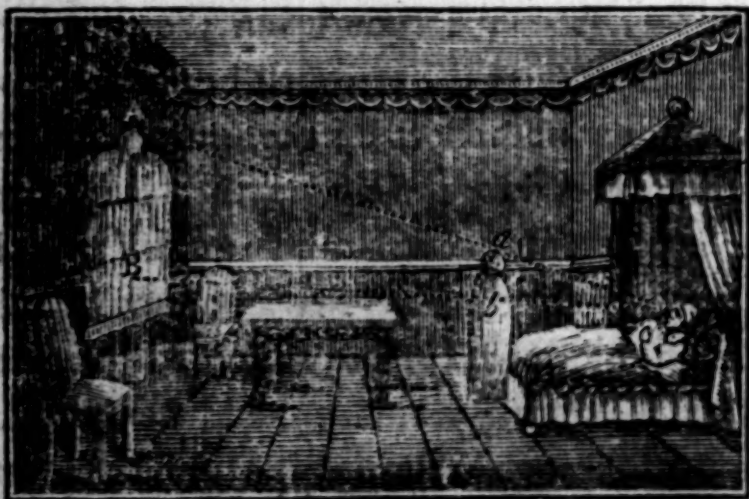


Of nutriment the animal would have little or no need, probably, in such a situation. As in most of the instances there was no room for any thing to be dissipated, no fresh supply would be wanting. The trees too, in which the toads were found, could not be deficient in moisture while green.

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## CHAP. XXIX.

### THE MONK'S GHOST.



THERE are few of my readers, I suppose, who have not heard of ghosts and apparitions: though as knowledge is more generally diffused, and people are become less superstitious, stories of this kind are by no



means so frequent as formerly. Some of the instances, that have been related, have existed only in the lively imaginations of timid people; or have been absolute fictions, framed for sinister purposes. Others have been real, but without any thing supernatural in them. The sight and hearing are the two most useful of our senses, but at the same time most liable to be deceived, particularly the sight. The circumstance I am about to relate would, no doubt, have terrified an ignorant and superstitious man, and probably have circulated as a true narrative of an apparition: happily it occurred to a man free from superstition, and well skilled in natural philosophy.

Mr. Schmidt, mathematical teacher at the school of Pforte, near Naumburg, which had formerly been a cloister, once happened to awake suddenly, as the morning began to dawn. On opening his eyes, he beheld with astonishment a monk, standing at the foot of his bed. Looking at him stedfastly, he appeared to be well fed; and his head, far from small, was sunk a little between a pair of very broad shoulders. The chamber was sufficiently secured; Mr. Schmidt alone slept

in it; and he was very certain, that no one would attempt to put a trick upon him in jest. He knew, also, that no part of his clothes, or any thing else, was hanging at his bed's foot. The figure exactly resembled that of a monk, clothed in a white surplice, the falling folds of which were very clearly to be distinguished.

Had an ignorant and timid man beheld this appearance, he would probably have covered himself up with the bed clothes, and firmly maintained, that the ghost of a monk had appeared to him. As the school had formerly been a cloister, many monks had been buried both in the church and church-yard, and it was currently reported among the vulgar, that the place was haunted. After such an evidence, therefore, the report would have been considered as true beyond all controversy.

Mr. Schmidt, however, was neither ignorant nor timid, and he immediately conjectured, that his eyes were deceived, though he could not imagine in what manner. He raised himself up a little in his bed, but the apparition did not move, he only saw somewhat more of it, and the folds of the sur-

plage were still more conspicuous. After a little while he moved toward the right, yet the apparition remained, and he seemed to have in part a side view of it; but as soon as he had moved his head so far as to have a slight glimpse of the bed's foot, the apparition retreated backward, though still with its face to the bed. Following the apparition quickly with his eyes, it retreated with speed, swelled as it retreated to a gigantic form, a rustling noise was heard, and—— at once the apparition was changed into the gothic window with white curtains, which was opposite the bed's foot, and about six or seven feet distant from it.

Several times after this Mr. Schmidt endeavoured, when he awoke, to see the same appearance, but to no purpose, the window always looking like a window only. Some weeks after, however, on awaking, as day began to dawn, he again perceived the monk's apparition at his bed's foot. Being now aware what occasioned it, he examined it narrowly. The great arch of the window formed the monk's shoulders; a smaller arch in the centre of this, his head; and the curtains, the sur-



plice. The folds of these appeared much stronger, than they did at the same distance by daylight. Thus the figure of the monk appeared plainer, nearer, and smaller, than the window would have done.

But you will ask, why did it appear so? To this question, by the help of the cut, I shall probably be able to give you a satisfactory answer.

Let the eye of the observer be at O. Mr. Schmidt himself confesses, that he is somewhat nearsighted, that is, incapable of distinguishing objects plainly at a distance. Now, some pressure upon the eye, or probably the moisture collected upon it, or some other cause, had brought the eye to such a state during sleep, that it was capable of distinct vision, or seeing objects distinctly at a greater distance than usual. That this was the case is clear, because the folds of the curtain appeared more distinctly than common. Accordingly the object at twelve feet distance appeared with the same degree of distinctness as in ordinary cases at six feet, and hence Mr. Schmidt conceived the idea of it's being only six feet distant; for the clearness, with which an object is seen, is one of the circumstances,



by which we judge of the distance of an object. The angle of vision,  $A O B$ , under which the window was seen, undergoing no change, the figure of the monk must have been seen under the same angle, and as it appeared to be at the foot of the bed, it would seem to extend only from  $a$  to  $b$ , and consequently to be much smaller than the window actually was, probably about the size of a man. Thus, as the figure of the window had a considerable resemblance to that of a monk in a surplice, the deception in the faint light of dawn was complete.

Still the apparent retreat of the monk, and his growing bigger, as the eye changed it's position, remain to be accounted for. These phænomena, however, are easily deducible from the same principles: for, as the idea of the smallness of the figure arose from the nearness, at which it was supposed to be, and this proceeded from the unusual clearness, with which it was seen; so, when the eye began to return to it's usual state, which was effected perhaps by the change of position, or when, by it's being directed to the foot of the bed, the window, or figure of

the monk, was seen with less clearness than the bed's foot, the same impression was made upon the eye, as if the figure had retreated from the foot of the bed; and as the angle of vision remained the same, the monk must have appeared to grow larger, in proportion as he retreated from *a b* to *A B*. At length, when the eye had returned completely to its former state, the window appeared as usual, and thus the phantom vanished. The rustling noise heard at the time must have been merely accidental, yet it would have tended more strongly to impress the belief of the reality of the apparition on a weak mind.

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### CHAP. XXX.

#### SOMETHING MORE ON THE SUBJECT OF SWINGING.

**WILLIAM** reminded his father of the promise he made him, which we mentioned in the 24th chapter, of explaining to him how any one could swing himself, without being impelled by another person. He had learned to do it, and wished to know the principle, on which his proceeding was founded.

*F.* "The whole of the art consists in a suitable alteration of the centre of gravity. When you swing yourself in a common swing, or in the pendulum swing as it might be very aptly termed, what is it you do, to set it in motion at first, and gradually to increase this motion?"

*W.* "I bend my body alternately backward and forward."

*F.* "When you bend your body backward, what follows?"

*W.* "The rope moves a little forward."

*F.* "And when you bend yourself forward?"

*W.* "The rope moves a little backward."

*F.* "Now, from what you have already learned respecting the pendulum, we may easily deduce an explanation of this."

"At first the rope hangs perpendicularly in the direction  $CA$ , p. 112. The centre of gravity of your body, therefore, is in  $A$ . On bending your body backward, the centre of gravity is carried backward, say to  $D$ : will the rope now remain at rest?"

*W.* "No; for the centre of gravity will descend to the lowest point  $A$ ."

*F.* " Thus a commencement of the motion is made. But will the centre of gravity remain at A, and the motion suddenly cease there?"

*W.* " No; it has already acquired some velocity, which will continue it's motion beyond A, in a curve A B, equal to D A."

*F.* " But when you, or rather your centre of gravity, has reached B, if you bend yourself forward, so as to carry the centre of gravity still farther from D, as to E for example, what will follow?"

*W.* " The centre of gravity will descend through the curve E A, and ascend, by the velocity it has acquired, through an equal curve A F.

" Now, I believe I can explain the continuance of the motion very well: for in F I bend myself back again, so as to carry the centre of gravity beyond F, and have a still longer curve to pass through in the third swing; and when I return, I do the same thing."

*F.* " Very right; and in this manner the curve is made longer and longer: a boy, who is used to it, as you know, can swing him-



self almost through a complete semi-circle, so as to make his feet touch the cieling of the room in which he swings. Yet I would advise you not to swing yourself quite so violently, for swinging with moderation is less dangerous, and affords sufficient exercise: leave violent and hazardous swinging to the russians."

*W.* "Why to the russians?"

*F.* "Because I believe there are no other people so extravagantly fond of swinging, or rendered so expert at it by practice. There is scarcely a house in Russia without such a swing as ours; besides which there are public swings of various kinds, not common among us, in which people of all ranks swing "for amusement."

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## CHAP. XXXI.

### RUSSIAN SWINGS.

*W.* "WHAT kinds of swings have the russians, then?"

*F.* "I will tell you; and as you have some knowledge of the science of mechanics,

a short account of them will be neither unamusing to you, nor difficult for you to understand.

“ In the first place, our common rope swing is universally known in Russia.

“ Beside this, there is the *katschel*, or ordinary russian swing, which consists, instead of a rope, of a perpendicular pole, moveable on an axis above, and provided with a seat at bottom, which is well secured, and so contrived, that the person cannot fall out.

“ Before the person that is to be swung, there is a place for an expert man, who sets the machine in motion. At first the swing moves slowly, and but a little way; it's velocity gradually increases, however, and at length the bold ruff gives the swing such a violent impulse, that it turns completely round it's axis: a movement that would unquestionably appal a person unaccustomed to it.

“ Both these belong to the kind of pendulum swings. Another kind consists of the wheel, or rotatory swings, which revolve circularly round an axis. These are of two sorts, perpendicular and horizontal.

“ The perpendicular rotatory swing consists of a strong horizontal axis, through which two pair of long and stout beams pass, forming four arms, at right angles with the axis, and with each other. Each of the arms consists of two beams, between which, at the end, a seat is suspended, moveable on an axis, so as to preserve it's perpendicular situation, while the arms move round. For the sake of security the arms are fastened to each other with cross pieces, so that the machine altogether does not appear much unlike a large water-wheel of a mill without the felloe and float-boards. The seats are secured with doors; and when the machine is made strong as it ought to be, it is perfectly free from danger. Each seat will hold two or three persons, but it is necessary, that the seats opposite each other should be nearly on a balance.

“ The machinery, by which this swing is set in motion, consists of a toothed wheel, made of iron, fixed to the axis of the swing, and a cog-wheel adapted to it, which is turned round by means of a winch. At first it moves slowly, and requires some exertion; but when it is set a going, if the weight be

equally distributed, it may be kept in motion with ease.

“ This kind of swing is common in Persia, Egypt, and some other countries, as well as Russia. Some years ago it was well known in England by the name of *up-and-down*, but in consequence of some accidents, and the interference of the magistrates, it came into disuse. Lately, however, it has been revived, and made it's appearance as a novelty at some of our fairs.

“ The horizontal swing is sufficiently familiar in this country under the name of *round-a-bout*. It consists of a large wheel, supported horizontally on a perpendicular axis, with wooden horses and carts fixed alternately at certain distances on the felloe. With us it is a play for children merely, but in Russia grown people are amused by it.”

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## CHAP. XXXII.

### THE ROCKING HORSE.

F. “ WHILE we are talking of swings, I may mention another kind, where the vi-



brating motion is effected, by means of a curved foot, or support. Of this sort are the cradle, and the rocking-horse, such as you had when you were a little boy, and which grown persons sometimes use by way of exercise. Have you any wish to consider the movement of the rocking-horse?"

*W.* "I am always glad to learn any thing, in which you please to instruct me."

*F.* "We will draw the figure of a rocking-horse, then, risen on it's hind legs. See p. 108.. The support is a segment of a circle,  $A E N$ , of which  $C$  is the centre, and  $C A$ ,  $C E$ ,  $C N$ , are radii. The support now touches the ground at  $A$ . On the horse sits a boy. The centre of gravity of the boy and the horse together is at  $G$ . Can the horse remain in this position?"

*W.* "No, certainly; for the centre of gravity is not supported, as the perpendicular line from the centre of gravity to the ground,  $G F$ , does not fall on the point  $A$ , on which the support bears."

*F.* "The consequence of this must be, that the fore part of the horse will descend by moving forward. In doing this every point of the curve  $A E$  will touch the ground

one after another, and the middle point of the curve, E, will come to the ground in D. When it has arrived here, where will the centre of gravity be?"

W. "In I, or so that D I will be equal to E G."

F. "But now will the centre of gravity be higher or lower than it was before in G?"

W. "It appears as if it were lower."

F. "Do not say, *it appears*; we must not be satisfied with appearances merely. It does, and must lie lower, as may be proved geometrically. For D I is equal to E G, as you very properly said just now: but E G is less than O G, as you have learned geometry enough to know\*, still more consequently must it be less than F G; so that D I must necessarily be less than F G; in other words the centre of gravity must be nearer the ground in I than in G.

"You will now be able to proceed with the argument yourself."

W. "As the centre of gravity descends from G to I, it will ascend from I to H, for the machine cannot suddenly stop when the centre of gravity has arrived at I, on ac-

\* Euclid, book 3, prop. 7.

count of the velocity it has acquired. From H it will descend again to I, and thence ascend to G. And in this manner it will go on alternately moving backward and forward."

*F.* "Thus the motion should continue indeed, did not the resistance of the air, and the friction of the support against the ground, constantly operate to retard it, so that the movement of the horse would soon subside into a state of rest, if it were left to itself. The boy sitting upon it, however, can easily keep it in motion, by bending his body alternately backward and forward, so as to alter the situation of the centre of gravity.

"The point C in this machine always moves in a right line from C to K, and from K to C.

"If the centre of gravity were in C, the horse would stand still as readily in the position in which it is represented in our figure, as in any other, just as a wheel will stand equally well on any part of its circumference. If the centre of gravity were higher than C, the horse would tumble over. But while the centre of gravity re-

mains below C, it will continue to vibrate like a pendulum, as will be obvious to you, from what I have already said."

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### CHAP. XXXIII.

#### FRIENDSHIP OF A GOOSE.

You have frequently been told, my dear children, that it is extremely wrong, to hurt or inflict pain on an animal; yet there are many, who do it from mere wantonness, without any malicious intention; as they are far from thinking, that a dog, a cat, a butterfly, or a cock-chaffer, has a sense of pain, as well as a man. It is still more unpardonable in grown persons, to beat and abuse mute beasts, incapable of expressing their feelings by their cries. How often does the brutal carman ill-treat his poor horse, unable to drag a heavy load over a slippery pavement, or up a steep hill! How often does the man, whose mind should be more enlightened, and feelings less blunted, lash along his jaded beast, lest his dinner should be delayed half an hour! Let your



own heart prompt you to treat with compassion those dumb animals, which have not the power of speech, to reproach you for your barbarity, and remember what is written, "The righteous man is merciful to his beast."

One of the advantages of natural history is, that in making you intimately acquainted with animals, it tends very powerfully to impress upon your minds the justice and compassion you owe them, of which you are so apt to lose sight. You will find in the structure of their bodies, their mode of life, their instincts, their capacities, their character, and their inclinations, so much that is admirable, and often that is noble, as will not fail to make you ashamed to treat with barbarity, or even to despise a creature, on which nature has employed so much care.

Of late years many authors have appeared as advocates in the cause of the brute creation; and, to give more weight to their arguments, have collected a number of examples, which set the worth of animals in a conspicuous light. I will relate a few of those which will probably give you a higher opinion of some animals, than you have

hitherto entertained; and chiefly such as display nobler qualities of the heart and mind, than men usually allow to what we call irrational creatures.

The first instance I shall adduce will be that of a singular friendship between a goose and a dog.

At Little-Grove, in Hertfordshire, was a goose of the species called Canada geese, which are fond of roaming at large, and do not like confinement. This goose, however, had contracted such a friendship for the yard-dog, that she continually kept near his house, in which he was chained, quitting it only when she went for food, and the moment she had eaten it, returning to her post. Thus she sat all day by the house of her favourite; though she never attempted to go into it, unless it rained. If the dog barked, she immediately began to cackle, flew at the person with whom she supposed the dog to be offended, and endeavoured to bite his legs. Sometimes she attempted to partake of the dog's food; but this the dog, who repaid the warmth of her friendship with apparent indifference, would not permit. When the rest of the poultry re-

tired to roost, she would not quit her dog without compulsion. In the morning, when driven to the field with the others, there was no getting her away from the gate of the courtyard, where she could at least have a sight of the dog, and before which she would sit the whole day. At length the owner of the faithful goose, resolved to leave her to follow her own inclinations, and not afflict her by any forcible separation. Being thus at liberty to obey the impulse of her attachment, she paraded about the yard at night with the dog, while he was on the watch; and in the day, when he took a walk into the village, she accompanied him, sometimes walking, sometimes flying, to keep pace with his trot. This extraordinary attachment continued till the dog's death, which happened two years after it had been first noticed. During the illness of the dog, she never left him, even to procure food, and would probably have been starved, if some corn had not been placed in a dish by the dog's house. The whole of the time she staid in the house, and would not suffer any one to come near it, except the person who brought food for the dog and herself. The end of

this goose was melancholy. After the death of the dog, she would not leave his house for a long time. At length, a dog of nearly the same size and colour being procured as his successor, the poor creature, deceived by outward appearance, and supposing it to be her old friend, went confidently into the house to the dog, who seized her by the neck, and killed her on the spot.

What renders this history remarkable is, that the friendship commenced after the goose was grown up; that it seemed to be entirely on one side; and that it was not the effect of habit, but apparently arose from gratitude and a sentiment of reflection; for it was universally believed at the time, that the dog had fortunately been the means of saving the goose from being devoured by a fox. The goose, who had probably more than once discovered traces of the fox, found herself secure under the protection, and in the company of the dog, and voluntarily repaid his services in kind, attacking the enemy, to whom the chained dog could only show his teeth.



## CHAP. XXXIV.

## AN EXPERIMENT WITH CORK-BALLS.

*Father.* “ William, get a bit of cork, and cut out of it a little ball: in the mean time, Caroline, thread a needle with silk, and I will show you an amusing experiment.”

The cork ball was cut out, and Caroline had strung it on a thread of silk.

*F.* “ We will now hang up this ball, so that it may be suspended freely, without touching any thing. William, take this stick of sealing-wax, rub it a little with this piece of flannel, and then hold it near the cork-ball.”

William did as his father told him: the cork-ball moved toward the sealing-wax, and stuck to it.

After it had stuck to the sealing-wax a little while, William separated them. He then presented the sealing-wax to the cork again, and, to his surprise, instead of moving toward it, it now retired before it, so

that William could drive it from one place to another, as he pleased. Thus it frequently happens, when two people hastily contract what they call a friendship for each other, after a short intimacy they conceive such an aversion, as to shun each other whenever they happen to meet.

“ This is very strange,” said William, “ what is the reason of it ?”

F. “ That it is strange, is very true ; but almost every thing that occurs in nature is equally so ; only what we see daily does not excite our wonder. And when it is asked, *what is the reason of it ?* it is seldom in our power, to give a solid answer. It would be much better, fairly to confess this, than to fancy we assign a reason, when we merely give a name to the phenomenon, or express it in words. For example ; ‘ what makes a stone fall to the ground ?’—‘ Gravitation,’ you will say.—‘ But what is gravitation ?’—‘ A power that impels bodies towards the earth.’—Here the word gravitation explains nothing ; it is merely a name for the phenomenon of falling or pressure ; and when you attempt to explain it farther, you merely describe the phenomenon.

“ In like manner, why does the cork ball first follow the sealing-wax, then adhere to it, and, after they have been separated, retreat before it? The answer is; it is the effect of *electricity*. But the word electricity no more explains this phenomenon, than gravitation does the other; it is merely a term to denote the cause of the phenomenon, with which we must not imagine ourselves acquainted, because a word has been framed to express it. We might as well have expressed it by x, y, or z, as the algebraists do unknown numbers, while they are finding their values\*.

“ The word electricity has been framed for this purpose from *electrum*, the latin

\* As few of my young readers, I imagine, know any thing more of algebra than the name, though it is on several accounts a science of great utility, with which I hope many of them will be acquainted hereafter, I shall just mention, that it is a kind of arithmetic; in which letters are employed to express numbers; for such numbers as are known, as the three numbers given in the rule of three, the algebraist uses the letters at the beginning of the alphabet; for such as are unknown, as the fourth number, or number sought, in the rule of three, he uses the letters at the end.

word for amber, in which the property was first discovered. But in this case, as in others, we cannot do better, than examine and compare the circumstances with which we are acquainted; that is to say, the appearances themselves, which will find us sufficient employment; for the alphabet of nature is more extensive even than that of the chinese, though happily more amusing. Accordingly we will vary our experiment a little. Cut out a couple more of cork balls, William.

“ Hang one of them up here by a thread; and hang up the other by a narrow slip of paper. Now rub your sealing-wax again, as you did before, and hold it near these cork balls: you will see a remarkable difference in the phenomena.”

William rubbed his stick of sealing-wax, held it near the cork balls, and they appeared to be attracted by it more forcibly, than that which was suspended by the silk. Having separated them from the sealing-wax, he held this near them again; when, instead of flying from it, as the former ball had done, they were as forcibly attracted



by it as before. It was exactly the same on a fresh repetition of the trial.

*F.* "Try the effect of a stick of sealing-wax without rubbing it first."

They were neither attracted nor repelled.

*F.* "And now of this key."

It had no effect upon the balls, either rubbed or unrubbed.

*F.* "And now of this glass rod."

Here again William found the same phenomena as with the sealing-wax. Without being rubbed the glass rod had no effect: when it was rubbed, it attracted each of the balls; and if that, which was suspended by the silk, were parted from it after they had been together a few moments, it was then repelled by it, while the other two were uniformly attracted by it.

"I do not understand it," said William.

*F.* "We will vary the experiment again a little, and then see whether we can make any thing of it."

Caroline was desired to string another cork ball upon a thread of silk; and this was hung up at a little distance from the first, that was also suspended by a silken thread.

First each ball was tried with glass, and with sealing-wax, to see whether they were acted upon alike.

Then both the glass rod and the sealing-wax were rubbed, or *electrified*: one of the balls was first attracted by the glass, and, after it had been separated from it, repelled. The sealing-wax was then presented to it, and immediately it was attracted by it strongly, and stuck to it. Thus the ball, that the glass repelled, was attracted the more powerfully by the sealing-wax.

On reversing the experiment, it was just the same thing. If the ball were first attracted by the sealing-wax, and afterward repelled by it, it was then the more forcibly attracted by the glass rod.

The action of glass, therefore, and that of sealing-wax, were opposite to each other.

An experiment was now made with both the balls suspended by silk.

First they were both attracted by the glass rod; they were then separated from it; the glass rod was removed to a distance, and the balls, thus left to themselves, mutually repelled each other.

It was precisely the same, when both were electrified by means of the sealing-wax.

But when one ball was electrified with the sealing-wax, the other with the glass rod, and they were then left to themselves, they attracted each other.

Little balls of sealing-wax, suspended in the same manner by silken threads, were slightly attracted by a stick of sealing-wax previously rubbed; but they neither attracted nor repelled each other afterward; nor were they repelled by the sealing-wax.

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## CHAP. XXXV.

### CONTINUATION.

*Father.* "At first sight these experiments seem tolerably puzzling; but we will try, whether they will not lead us to some notions, that may contribute toward their explanation.

"Sealing-wax and glass, when rubbed, exhibited marks of electricity: iron did not, either with or without rubbing.

“ Thus we find there are bodies, in which native electricity may be excited, and others, in which it cannot. Hence the former are called *electrics*; the latter, *non-electrics*. Among the former are glass, sealing-wax, amber, pitch, sulphur, silk, &c. Among the latter, metals, water, paper, green wood, &c.

“ The cork balls suspended by silken threads, after being touched by an excited electric, exhibited an electric property, which the electric had imparted to them; but the balls of sealing-wax did not.

“ Electricity may be distinguished, therefore, into *native* and *communicated*. Bodies which exhibit the former do not receive the latter; and, on the contrary, no native electricity can be excited by rubbing in those, to which electricity may be communicated from others.

“ The cork balls exhibited this communicated electricity, when they were suspended by silken threads; but not when suspended by a flaxen thread, or a slip of paper. The silk, therefore, appeared to confine the electricity communicated to the balls, so that it could not escape from them; the other



substances, on the contrary, to give a passage to it.

“Hence we may distinguish bodies which do not conduct electricity, *non-conductors*, and bodies which do, *conductors*. Bodies that are *electric per se*, as glass, sealing-wax, silk, &c. are non-conductors, as appears in some measure from our little experiments: the non-electrics, as metals, waters, &c. are conductors of electricity. A non-electric body, when separated from other non-electrics by means of an electric body, or non-conductor, is said to be *insulated*. Thus the cork ball was insulated by the filken thread, so that the electricity imparted to it could not escape.

“When electricity had been communicated to the insulated cork balls from sealing-wax, the native electricity of sealing-wax repelled them: so when it was communicated to them from the glass, they were repelled by the glass. On the other hand, when they were electrified by the sealing-wax, they were repelled by the glass, and the contrary.

“Hence we are naturally led to infer, that there are two opposite kinds of elec-

tricity, which mutually attract each other. These we may call the *vitreous* electricity, and the *resinous*; or, as they appear to have opposite powers, *positive* and *negative*. The little experiments abovementioned disclose to us the following grand law, which is confirmed by all that have hitherto been made.

“ *Similar electricities repel each other; opposite electricities attract.* ”

“ Thus when the two insulated cork balls were both electrified by glass, or by sealing-wax, they repelled each other. When one was electrified by glass, the other by sealing-wax, they attracted each other.

“ It is in consequence of the same law, that light bodies are first attracted by the rubbed sealing-wax, and then repelled by it.

“ Burn this little bit of paper to ashes; rub the stick of sealing-wax, and hold it over them. See how the little light ashes are first attracted by the sealing-wax, and then repelled by it. As soon as they have received electricity from the sealing-wax, the similar electricities of the sealing-wax and ashes

repel each other, so that the ashes are driven off from the sealing-wax.

“ Now cut out a couple of little puppets of thin paper, Caroline : you shall see how prettily they will dance about.”

Caroline cut out the puppets, laid them upon the table, and held over them the stick of sealing-wax previously rubbed. Immediately they rose up, and danced about, or stood upon their feet, and bent toward this side or that, according as the sealing-wax was moved.

*F.* “ Now can you explain these phenomena from the law I mentioned above ?”

*W.* “ In some measure ; yet I do not clearly comprehend the reason of the first attraction. The law says, opposite electricities attract each other ; but the cork balls, or paper ashes, before the sealing-wax has touched them, have no electricity, so that here the law seems to me not to apply.”

*F.* “ You are very right ; yet we may suppose the case to be thus. Both kinds of electricity are present in all bodies ; but as they have a strong attraction, or, as chemists say, a strong affinity to each other in their natural state, they are intimately

united, and *saturate* each other; that is, they are united in such proportions, that the powers of the one balance the powers of the other. Thus neither of the electricities is at liberty to exert it's powers; so that a body, in which the two electricities are united, or in equilibrium, will exhibit no appearance of electricity; and in this state are the cork balls at first.

“ But when this equilibrium is destroyed in the sealing-wax by rubbing it, and one of the kinds of electricity, the negative, is thus set free; this is capable of exerting it's effects on those bodies, that are within it's *sphere of action*.

“ Thus, when the cork ball is within this sphere of action, the negative electricity of the sealing-wax repels the negative electricity, that was before in the cork ball in a state of equilibrium, and attracts the positive, by means of which the ball itself, which is very light and moveable, is attracted.”

W. “ But then the repulsion of the negative electricity should repel the ball at the same time, and thus one effect counterbalance the other.



*F.* “Your objection is very proper. Yet, if all bodies in their natural state contain a portion of both kinds of electricity, the difference between conductors and non-conductors must consist rather in the degree of their capacity for conducting electricity, than in perfectly opposite states. Hence the cork ball, we may presume, is not so perfectly insulated by the silk, but that it's negative electricity may pass more easily along it, than the positive can through the air, which is a very bad conductor, particularly when dry, for it differs much in this respect, according as it is dry or moist.

“Thus when the cork ball is not insulated, the attraction is more powerful, as you observed in the ball suspended to the flaxen thread; as in this case the negative electricity finds a freer passage out of the ball, and leaves the positive more at liberty, to be attracted by the negative of the sealing wax.

“There is another mode of accounting for it, by supposing the attractive power of the opposite electricities to act with more force, than the repulsive power of similar electricities. Both these suppositions, how-

ever, you will consider merely as what they are, hypotheses ; for neither of them is perfectly satisfactory. At present, indeed, though we are acquainted with many effects of electricity, we have but a very superficial knowledge of the nature of this truly wonderful power, the action of which is unquestionably of very great extent and importance in natural phenomena : by pursuing our investigation of these, we may hereafter attain more clear and solid ideas of it.

“ For to-day this may suffice : some other time I will show you many more pleasing experiments in this beautiful and amusing branch of natural philosophy.”

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## CHAP. XXXVI.

### FILIAL AFFECTION OF TWO YOUNG RATS.

I HAVE already related an anecdote of the friendship shown by a goose toward a dog ; but the following story exhibits a still nobler sentiment in animals, which are commonly abhorred by us. That in the brute creation

mothers have great love for their young, and will even sacrifice themselves in their defence, is well known, and deserves our admiration; but the following instance of filial affection, and the gratitude of young animals toward a parent, is much more to be admired.

Mr. Joseph Purdew, lying abed one morning reading, had his attention called off from his book by a noise, resembling that of rats climbing up a wainscot. The noise ceased for a moment, and was renewed again. His bed was but at a little distance from the side of the room, and he narrowly observed the place, from which the noise seemed to come. It was not long before he saw a rat make his appearance at a hole, without any noise, look cautiously all around him, and after a little while withdraw. Presently the rat came again, with a large old rat, which he led by holding it's ear in his mouth. With them came a second young rat. The two young rats left the old one at the mouth of the hole, ran about the room picking up the crumbs, which had fallen from the table the preceding evening at supper, and carried them to the old one. Mr. Purdew, astonished at this attention in such animals, perceived, that the old

rat was blind, and could only find the crumbs the young ones brought by feeling about for them. When this affecting scene had continued a little while, some person came into the room. As soon as the young rats heard the noise, they gave the old one intimation of it by a cry, and did not endeavour to escape themselves, till the old one had re-entered the hole, into which they followed him.

What think you of this fact, my young readers? Did not these animals exhibit a pattern of filial affection, sufficient to put many, who pride themselves in the possession of reason, to the blush? How often do we find, that parents, who have done every thing in their power for their children, and denied themselves not only pleasures, but even the necessaries of life, the better to educate them, are deemed a burden by those very children, when they are grown old and infirm, and either totally neglected by them, or poorly and grudgingly maintained! May none of you ever be liable to this shameful reproach; but think of the good young rats, that fed their blind and aged parent.



## CHAP. XXXVII.

## HISTORY OF A WILD GIRL.

How much reason have you, my young readers, to thank Providence, for having caused you to be born and brought up among civilized men; for what would you have been, had you, bereft of parental care, and left to yourselves, grown up remote from human society! It is through the means of society alone, that we become human creatures. Even the savages, as they are called, of America and the South-Sea islands, live together in society; and in consequence are not wild, they are only less polished than europeans. Do you wish to know what man would become, if deprived of human society, and uneducated by his fellow men, you may learn it from the following account of a wild girl, which is well worth your reading.

In the year 1731, as a nobleman was shooting, at Songi, near Chalons, in Champagne, he saw something at a distance in the water, which he took for a couple of birds, and at which he fired. The supposed birds

avoided the shot by diving instantly under the water, and, rising at another place, made to the shore, when it appeared, that they were two children, about nine or ten years of age. They carried ashore with them several fishes, which they tore in pieces with their fore-teeth, and swallowed without chewing. As they were going from the shore, one of them found a rosary, probably dropped by some traveller, at which she testified great joy, by screaming and jumping about. In order to keep it to herself, she covered it with her hand; but her companion, who perceived this, gave her such a blow upon the hand with a sort of club, that she could not move it. With her other hand, however, she struck her companion in return such a blow upon the head, with a similar club, as brought her to the ground, with a loud shriek. The victor made herself a bracelet with the rosary; but she had still so much pity on her companion, that she covered her wound with the skin of a fish, which she stripped off, and bound it up with a slip of the bark of a tree. They then parted. The girl that had been wounded returned to the river, and was never after seen; the other went to the

village of Songi. The ignorant inhabitants were frightened at her singular appearance, for her colour was black, and she had on a scanty covering of rags, and skins of animals. They set a great dog at her: but she waited his attack, without stirring from her place, and, as soon as he was within reach, gave him such a blow on the head with her club, as laid him dead on the spot. Unable to gain admission into any house, for every door was shut against her, she returned into the fields, climbed up a tree, and there took her repose.

The viscount d'Epinoy, who was then at his seat at Songi, offered a reward to any one, who could catch this wild girl. As it was supposed she would be thirsty, a bucket of water was placed under the tree, to entice her down. On awaking, she looked cautiously around, came down, and drank; but immediately ascended to the summit of the tree, as if she thought herself not otherwise secure. At length she was allured to come down by a woman, who walked under the tree with a child in her arms, and offered her fish and roots. When she had descended, some persons lying in wait seized her, and

rat was blind, and could only find the crumbs the young ones brought by feeling about for them. When this affecting scene had continued a little while, some person came into the room. As soon as the young rats heard the noise, they gave the old one intimation of it by a cry, and did not endeavour to escape themselves, till the old one had re-entered the hole, into which they followed him.

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conveyed her to the viscount's seat. At first she was taken into the kitchen, where she fell upon some wild fowl, and ate them up, before the cook missed them. A rabbit being offered her, she immediately stripped off the skin, and devoured the flesh.

An opportunity of observing her with more ease was now obtained, and it was found, that the black colour of her skin was accidental; for after she had been repeatedly washed, her naturally fair complexion appeared. Her hands were upon the whole well-formed, only the fingers, and the thumb in particular, were uncommonly strong, which no doubt was ascribable to her frequently climbing trees, as she would swing herself from one to another like a squirrel.

The viscount d'Epinoy delivered her into the care of a shepherd, recommending to him to be extremely attentive to her, under a promise of paying him well for his trouble. On account of her wildness she was commonly known by the name of the shepherd's beast. It cost a great deal of trouble, to render her a little tame. She was very dexterous at making holes in the walls or roof, and would creep through an aperture so small,



that an eye-witness could not conceive how it was possible. . . Once she eloped in a severe frost, during a heavy fall of snow, and after a long search was found sitting on a tree in the open fields.

Nothing was more astonishing than the swiftness and agility, with which she ran. Though latterly long illness and want of exercise diminished her speed, it was always surprising. She did not take long steps like other people, but her run was rather a *flying trip*, which was more like gliding than walking. Her feet moved with such quickness, that their motion was scarcely discernible. Several years after she had been caught, she was capable of outstripping wild animals, as she proved to the queen of Poland in 1737: for, being taken out on a hunting party, she ran after rabbits and hares that were started, caught them presently, and brought them to the queen.

The quickness of her eye was equally astonishing. In a moment she could look every way round her, with scarcely turning her head, which was very necessary for her security, and procuring her food, in her wild state.

Both the girls used to spend their nights on trees. They laid down on a bough, held themselves fast with one hand, and rested their heads on the other. In this situation, according to our maiden's account, they slept very soundly.

In her savage state she had no language, but a sort of wild scream, which sounded frightfully when she was in anger, and particularly when a stranger attempted to take hold of her. Long afterwards her speech had something wild, abrupt, and childish; but when she was a little civilized, she appeared to be a quick lively girl.

There was nothing, from which she was more difficult to be weaned, than eating flesh and vegetables raw. Her stomach could not bear dressed victuals, so that she fell into one disease after another, though raw food was allowed her occasionally. Perhaps the change was attempted with too little caution. At first she was led by this propensity to play some laughable tricks. Once the viscount had a great deal of company, and she sat at table with them. None of the thoroughly dressed and high-seasoned dishes being to her taste, she started up, vanished like lightning,

filled her apron with live frogs from the nearest pool, hastened back, and bestowed them among the guests with a liberal hand, joyfully exclaiming, as she distributed her agreeable present, "here, here, take some!" It is easy to imagine how the company were delighted with the frogs hopping all over the plates and dishes, while the little wild girl, astonished at the slight estimation in which they seemed to hold her delicious morsels, busied herself in catching the frogs that leaped about the floor, and replacing them on the table.

In the year 1732, this remarkable maiden was baptized by the name of Maria le Blanc. On account of the change in her mode of life she was often ill, and, after the death of her patron, spent the remainder of her days in a convent.

How this child came into that wild state, and in what country she was born, were circumstances, that could never be known with certainty. It was conjectured, however, that she was by birth an esquimaux, and brought to Europe in some ship: for, when she had learned to talk, she said, that she had twice crossed the sea; gave a description of boats,

resembling those of the esquimaux; and once, when she was shown a series of delineations of people of different countries, she seemed agreeably surprised on coming to that, in which the esquimaux were represented.

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## CHAP. XXXVIII.

### OTHER INSTANCES OF WILD BOYS AND GIRLS.

AMONG all the instances we have of wild persons, the preceding is one of the most remarkable: it may not be amiss, however, to give a concise account of a few more.

In the year 1661, a boy apparently about nine years old was found in a forest in Lithuania, among the bears. He was well-made, and his countenance was pleasing, but he was extremely wild. It proved impossible to tame him, and accustom him to the clothing or food of civilized men.

In 1694, a young man of twenty was found among a herd of bears, in Lithuania likewise, on the frontiers of Russia. He is



said to have been all over hairy, and to have walked on both hands and feet. He displayed very few marks of reason, had not a human voice, and was difficult to tame : by degrees, however, he learned to stand upright against a wall, eat common food, and to speak a little, though in a hoarse and scarcely intelligible manner. He could not recollect any thing, that had befallen him in his wild state.

In 1717, a wild girl of nineteen was caught near Zwoll, in Oberyffel. She had been lost by her parents, when only sixteen months old. Her skin was brown, hard, and hairy : the hair of her head, long and thick : her speech, an uncommon stuttering : her food, in her wild state, green herbs, and leaves of trees. She walked erect : wore an apron of straw, which she had made herself : was very shy, and difficult to be taken : but soon became familiarized to society, and learned to talk and to spin.

In the year 1719, two wild boys were caught on the Pyrenees, where they skipped about from rock to rock like the chamois.

While we are on this subject we must by no means omit to mention *Peter the wild boy*, as he was commonly called. This boy

was found in the woods near Hamelen, in Hanover, when his majesty George I was hunting, in the year 1725. He was supposed to be then about twelve years of age, and had subsisted in those woods upon the bark of trees, leaves, berries, &c. for some considerable length of time. How long he had continued in this state, indeed, is uncertain: but that he had formerly been under the care of some person, was evident from the remains of a shirt-collar about his neck, when he was found. In the following year he was brought to England; and great pains were taken, to instruct him: but he could never be taught to articulate any words, except his own name, Peter, and that of king George. He learned to hum a few simple tunes, however; and was so delighted with music, that, if he heard any one play on an instrument, he would dance and caper about, till he was nearly exhausted with fatigue. He was likewise made to understand every thing that was said to him, respecting the common affairs of life. In his nature he was gentle and timid, so that he would suffer himself to be governed by a child; yet he was subject to the passions of anger, joy, &c. Upon the approach of bad

weather he always appeared fullen and uneasy; and at particular seasons of the year he had a strong propensity for stealing into the woods, where he would feed eagerly upon leaves, beech-mast, acorns, and the green bark of trees; but if he rambled far from home, he could not find his way back again.

Peter was about five feet three inches high, in his countenance there was nothing ugly or disagreeable, and he retained a fresh healthy look in his old age. He died in february, 1785, when he was supposed to be about seventy-two years old.

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## CHAP. XXXIX.

### SOME OBSERVATIONS ON CHYMICAL AFFINITY, SOLUTION, AND CRYSTALLIZATION.

“ You are going to show us something curious again to-day, father!” said Caroline, as she perceived upon her father’s table the microscope, through which she had seen with so much astonishment the animalcules of infusion.

F. "I am: and I shall do it with a great deal of pleasure, as there is no amusement more innocent, than what we derive from the contemplation of nature. It gives me much satisfaction, therefore, to find you have a taste for such amusements. A few days ago, the microscope exhibited to you swarms of living creatures: by way of change you shall now see inanimate objects, yet not less wonderful."

"What are they?" exclaimed William and Caroline, with eager expectation.

F. "You shall observe the process of *crystallization* in *solutions* of salts."

William and Caroline had never before heard these technical terms, or, if they had heard them, had no clear ideas of their signification. Mr. Goodwyn had often told them, that, on all occasions, they should endeavour to obtain as clear ideas as possible of the things signified by words; and whenever they heard any, which they did not understand, should ask him to explain their meaning. He was persuaded, likewise, and had found by experience, that technical terms, though generally considered as puzzling, are in fact more easy to be understood: and the



reason is obvious: common words are generally used in a looser sense, and frequently with several different meanings, while technical terms have usually one precise signification only. Accordingly, William requested an explanation of the terms *solution* and *crystallization*.

F. "I will endeavour to satisfy you in this respect, if you will be attentive. Observe, I throw some of this salt into this glass of water. At first you see the particles of salt, as they were when dry: but they do not continue so long, they gradually diminish: I stir it; you see no more salt in a solid form, the water only looks a little turbid: when it has stood a minute or two, it will be quite clear. — See, there is now nothing in the glass apparently but clear water: yet the taste will convince you, that there must be a great deal of salt in it. Taste it, William."

W. "It tastes salt, indeed."

F. "Here then we have a fluid, that contains another substance, the component parts of which are equally invisible to the naked eye and the best magnifying glass. The connexion between the minutest particles of the substance, that was at first visibly *mixed* with

it, is loosed; these particles are intimately united with the particles of the water, and they are no longer distinguishable from each other. The whole is become an uniform substance, different from what either was before. Such a substance formed by the intimate union of two or more substances, is called a *solution*. The process by which they are united is called *dissolution*; and the solid substance is said to be *dissolved* in the fluid, which is called the *solvent*, or *menstruum*. As the change is most apparent in the solid, the fluid is commonly considered as the active substance; and this idea is confirmed by our applying an active expression to the fluid, and a passive to the solid. But there is little room to doubt, that a mutual action takes place between them; for in some cases the solid seems to exert the active power."

W. "But what is the reason, that the particles of the salt unite so intimately with the particles of the water?"

F. "That is a question, to which it is not in my power to give you a satisfactory answer. Here, as in many other natural phenomena, I must remind you of the expression of the great Haller, who zealously

purfued the ftudy of nature, and, feeling the narrow limits of the human underftanding, exclaimed :

‘ ’Tis not for mortal mind to penetrate into the fecret receffes of nature.’

“ All that we can fay, which in fact is no more than expreffing the phenomena in words, is, the particles of the water, and the particles of the falt, in a certain *temperature*, that is, in a certain degree of warmth, have a ftronger attraction for each other, than that by which the particles of the falt are held together. Thus the cohesion between the particles of the falt, which rendered it a folid fubftance, is deftroyed by a ftronger power. Subftances that have this attraction for each other are faid to have an *affinity*, or *chymical affinity*. The degree of this affinity varies, it being ftronger between fome fubftances than others. Hence, if we add to a folution a third fubftance, which has a ftronger affinity for either of the two that compofe the folution, than thefe two have for each other, thefe will feparate, and that which has the ftrongeft affinity for the fubftance added will unite with it, leaving the other in it’s former ftate. This is called *elective attraction*. If

this elective attraction take place between the substance added and the fluid of the solution, the solid before dissolved in it subsides to the bottom. This process is named *precipitation*; the matter at the bottom of the vessel is called a *precipitate*, and is said to be *precipitated* from the fluid, in which it was dissolved, by the substance added."

C. "Will you let us see an example of it, father?"

F. "Willingly. Fetch me a bit of chalk, a little vinegar, and some pearl-ashes, and we will make the experiment."

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## CHAP. XL.

### SOLUTION AND PRECIPITATION.

CAROLINE having fetched the things she was desired from the kitchen, the chalk was put into the vinegar, in which it dissolved, so that nothing more of it was to be seen. Some pearl-ashes were then added to the solution, which became turbid, and the chalk gradually subsided to the bottom in the form of a white powder.



F. "This experiment, I presume, you can explain without difficulty."

W. "The vinegar, in which the chalk was first dissolved, has a stronger affinity for the pearl-ashes, than for the chalk, and in consequence quits the chalk, to unite with the pearl-ashes."

F. "Right. But now tell me, do you suppose, that solid or dry substances can dissolve one another?"

W. "I should think not."

F. "In this you think justly; for in every solution it is requisite, that one of the substances be in a fluid state. It is not necessary, however, that either should be fluid by nature: you may reduce one or both of them to a state of fluidity by means of heat, in other words, you may melt them, and then they would be capable of forming a solution. This is called a solution *in the dry way*, to distinguish it from the case where one or both of the substances are naturally fluid, which is called a solution *in the moist way*."

"Thus, for example, solutions of salt, sugar, or gum in water, of chalk in vinegar, of resins in spirit of wine, and of silver in aqua fortis, are called solutions in the moist

way. So also is that solution which takes place between two fluids, as water and vinous spirit; though this is commonly called a mixture, but improperly, for here an intimate union, or proper chymical combination takes place, wherefore it should be expressed by the term solution.

“ Solutions in the dry way are such as of wax in melted lard, tin and lead melted together, &c.

“ Precipitation likewise is distinguished in the same manner. Thus it is called a precipitation in the moist way, when the solution is naturally fluid, as in the experiment we just now made with the chalk and vinegar; and a precipitation in the dry way, when the solution must be rendered fluid by fire, as of lead in sulphur, called galena, which being melted, the addition of an alkali, for which the sulphur has a stronger affinity, will precipitate the lead.”

*W.* “ If I remember right, you said at first, there were solutions consisting of more than two substances: but in the instances you have given, the solutions have contained only two, and when a third was added, one

of them was precipitated, and only two remained dissolved."

F. "Examples of more compound solutions are not difficult to find: such as sugar, water, and vinous spirit, which form a solution of three ingredients; or common salt, salt-petre, and water; and in the dry way, lead, tin, and bismuth, or gold, silver, and copper; with many others."

C. "There is one thing I would ask; can we dissolve as much of one of the substances in the other, of salt in water for instance, as we please?"

F. "In some cases in the dry way we can; but not in the moist. { A certain quantity of a fluid, as you seem to imagine, can dissolve only a certain quantity of a solid. When the fluid has dissolved as much of the solid as it can, it is said to be *saturated* with it; and if more of the solid be added, this will remain at the bottom of the vessel undissolved.

"The proportions, in which different substances are soluble in others, vary, and depend in some measure on the temperature of the solvent. Thus a given quantity of water will dissolve more of sugar than of alum,

and boiling water will dissolve more of either than cold; though, on the contrary, cold water will dissolve more magnesia than hot. It is also to be remarked, that water, after it is saturated with one salt, is still capable of dissolving a certain quantity of another.

“ It is a singular circumstance too, that a considerable quantity of salt may be dissolved in water, without the water’s rising perceptibly higher in the vessel, in which it stands; the space, that the two substances occupy after solution, not being equal to that they both occupied when separate.”

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## CHAP. XLI.

### CRYSTALLIZATION.

*Father.* “ As I have now given you some insight into what is most important concerning solution, I may proceed to explain to you briefly what is meant by crystallization.

“ The particles of many substances have a disposition, in passing from a fluid to a solid state, to arrange themselves in regular



figures. This is called crystallizing. Thus the freezing of water is a true crystallization, of which we frequently see beautiful specimens on our windows in winter mornings. So, likewise, if part of the water of a saturated solution of any salt be evaporated, so much of the salt, as the remaining water cannot keep dissolved, will return to a solid state, and in doing this, crystallize. You shall see an instance of it in the salt we dissolved just now."

The microscope was now adjusted, so that the light fell properly on the slide, on which a tolerably large drop of the solution of salt was put. William and Caroline looked in by turns. At first nothing but a clear fluid was visible. Presently Caroline perceived a small transparent solid point in it, which appeared no larger than a small grain of sand, though the microscope magnified the diameter of an object two hundred times. More such points soon formed in different parts of the drop, but first round the edge.

"Observe these points attentively," said Mr. Goodwyn; "they are the commencement of crystallization, the first combination of the component particles of the salt, at

least as far as we can discern, that were dissolved in the water, and are now set free from it. You will soon perceive a change in them."

In fact, it was not long before our young observers saw squares of different sizes, as regular as a geometrician could have drawn, form around these points. From the point, as a centre, proceeded straight slender lines to the corners of the square, crossing each other at right angles, and other slender lines, parallel to these, filled up the intervals. It was a pleasing sight. Now here, now there, a new square arose; the largest in the middle of the drop. Here and there other figures less regular appeared; probably because the particles of salt were prevented from assuming their proper form by some obstacle. At length the field of the microscope was completely bestrewed with such figures; no more fresh ones appeared; and, when the slide was withdrawn, nothing but the dry salt was seen on the glass.

William and Caroline were so much amused, that they desired to examine another drop, which exhibited just the same appearances.

As usual, William was ready with his old

question, which is as easily put, as it is commonly difficult to answer: "What is the cause of this?"

F. "Of the primary cause we know no more in this case, than we do in many others. The component parts of substances have a disposition to unite firmly together, or an *attractive* power for each other. This power is in great measure counteracted by a certain degree of heat in quicksilver, water, and melted metals; and by the attractive power of the menstruum in solutions. If the degree of heat be diminished in the former instances, the component parts of the substances will unite into a solid. The same thing will take place in solutions, either by cooling, or by diminishing the quantity of the fluid menstruum, while that of the solid dissolved remains the same, or by the addition of a third substance.

"I have said it may be effected in solutions by cooling, which is the case with such substances as are soluble in greater quantity in a hot menstruum than in a cold. Of this we have an instance in saltpetre, which dissolves in much greater quantity in hot water than in cold; so that if you saturate

boiling water with saltpetre, and then let it cool, a considerable portion of it will shoot into crystals, in much the same manner as ice in a vessel of water when it freezes.

“The experiment, that we have just made with the salt and water, or brine, is an example of the second mode. The water in the drop upon the slide evaporated by degrees, so that the remaining water became less and less capable of holding all the salt in solution, and in consequence the particles of the salt gradually united together. What you here saw in miniature is executed on a larger scale in salterns, or salt-works. In these the brine of a salt spring, as at Namptwich and Northwich in Cheshire, and Droitwich in Worcestershire, or sea-water, as on various parts of our coasts, is conducted into large pans, under which a fire is kept, which evaporates the water, and the particles of salt unite into cubic crystals. Common salt will not crystallize by cooling like saltpetre, for hot water dissolves very little, if any, more of it, than cold; indeed it crystallizes best when the water is kept pretty hot.

“In the last mode the crystallization is effected by the addition of a substance, which



has a stronger affinity for the solvent. Thus, for example, crystallization is effected in a solution of salt, by the addition of spirit of wine. In this case, however, the crystals are smaller, and not so regular, of which I will give you the reason. When particles are obliged to unite suddenly, they cannot unite in such regular order, or in such large bodies, as when they are attracted toward each other slowly and gradually. When spirit of wine is poured into a solution of salt, it combines quickly with the water, so that the salt is as quickly set free to unite; which does not happen when it is left to unite by gradual evaporation, or cooling; and the more slowly either of these takes place, the larger and handsomer will be the crystals produced.

“Salts, such as saltpetre, common salt, and the like, show a peculiar disposition to crystallize: and hence some have imagined, that every crystallization must be a salt, and require a solution in the moist way. But this is an erroneous opinion: for crystals are formed in the dry way, as in melted metals, and glass, when very slowly cooled, and without the presence of any salt, as in pure water that freezes. Crystallization,

however, requires, that the particles be in a state to move freely ; whence it is most perfect in liquid solutions, and much less so in metals, the fluidity of which, when melted, is always inferior. Even the fume, or smoke, that ascends from certain bodies, assumes particular figures, where it attaches itself."

*W.* " Last night, by candle-light, I saw something like a little black worm floating in the air, which settled on my paper. At first I thought it was something alive ; but when I found it was not, I brushed it off, and it left a black mark on the paper, and on my finger. Was it smoke, that had united into such a body in the air ?"

*F.* " Certainly ; and it is a very frequent appearance, when we burn candles that emit much smoke.—But to return to our crystals, did you ever observe the little grains of salt with attention ?"

*C.* " O yes ; I have often observed them : they commonly look like little square funnels, close at the point."

*F.* " Very true ; and larger in some salt, smaller in other. These little funnels are the groundwork of cubical crystals, fix of them uniting by their points, and the hol-

flows of the funnels being filled up by additional matter.

“ The crystals of every kind of salt have their particular figure, salts varying greatly from each other in this respect, as we shall hereafter have some other opportunity of observing. But to enable them to retain this figure, it is always necessary, that a certain portion of water should be united with the particles of the salt. This is called the *water of crystallization*; and if it be expelled from the crystals by heat, these lose their crystalline form, and fall into a dry powder, which, however, retains all the properties of the salt.”

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## CHAP. XLII.

### NATURAL SALT-PANS.

*Father.* “ I just now observed to you, that what you had observed in miniature was performed in an extensive way in the preparation of salt. This, however, requires proper buildings and implements, which cannot be erected and provided without confi-

derable expense. You see salt on the table daily ; but you little imagine what buildings must be erected, vessels and implements procured, fuel expended, and labour employed, before we can obtain it in the form in which we have it for use.

“ Yet there are countries, where these are not requisite, nature performing the whole process. Hollow places in the low grounds there answer the purpose of our large and expensive pans ; while the air and the sun perform the office of evaporating the brine, for which we are obliged to employ much labour and fuel, before we can bring the salt to crySTALLIZE.”

*Caroline.* “ Where are those countries ? ”

*F.* “ At the Cape of Good-Hope. You know where that is.”

*C.* “ Yes ; it is the southern extremity of Africa, where the dutch had a settlement, which we took from them in the beginning of the present war with them.”

*F.* “ At the Cape of Good-Hope, as we are informed by Dr. Thunberg, who has given a valuable description of that country in his travels, there are large places, or na-



tural salt-pans, in which a great deal of brine collects during the rainy season."

C. "Is there a particular rainy season there, then?"

F. "Yes; but of that another time.

"The water of this brine gradually evaporates, and leaves behind good salt, which the people of the country collect for their use. In this manner they are supplied by nature with all the salt they want, without the least assistance from art.

"When the rainy season is over, a very brisk evaporation of the water ensues, occasioned partly by the great heat of the sun, partly by the violent winds. The salt then crystallizes, and falls to the bottom. The crystallization takes place most powerfully in november and december, and in the middle of the day, from ten o'clock to three. During this time the salt may be seen forming a kind of pellicle, or thin skin, on the surface of the water, before it becomes so heavy as to sink to the bottom. The salt produced in this way is very fine, and the crystals are driven to the north-west side of the pool by the blowing of the south-east wind, where they must be immediately collected. If this

be not done, the salt accumulates, and falls to the bottom in layers, or flakes, from which a coarser kind of salt is formed, in larger grains, and mixed with impurities, which give it a grayish colour. This salt is used only to preserve meat, or flesh; the finer or whiter salt is employed for the table, and for salting butter.

“ Some of these natural salt-pans are so large, that it will take half an hour to walk round them; and when they are covered with salt, they resemble a lake frozen over, which has a singular appearance in the summer, and in such a climate.

“ These pools are often at a distance from the sea, and at considerable heights. Their water has no connexion with that of the ocean, but is produced entirely by the rain, which falls in the spring, and evaporates in the summer. The soil every where abounds with salt: accordingly the rain, which flows down from the higher grounds, dissolves this salt, and carries it along with it, till it arrives at a hollow: there it stops, and gradually evaporates, till it is so diminished, that crystallization follows.”

## CHAP. XLIII.

## THE SPINNING-WHEEL.

AMONG other female occupations, Caroline had lately learned to use a spinning-wheel, which had been presented to her by her god-mother, and was diligently employed at it, when her father came in.

“Do you know,” said Mr. Goodwyn, after looking attentively at his daughter’s industry, “how it is, that the thread winds from your hand upon the bobbin?”

*Caroline.* “You are laughing at me now, father. Do not I see how swiftly the flyer turns round with the bobbin? how then can the thread avoid being wound upon it?”

*Father.* “You think, it cannot. Well, take the flyer out with the bobbin, and turn them round with your hand; or, which is better, take the string that passes over the pulley of the bobbin, and place it where the other is, that passes over the pulley of the flyer. Now you perceive, when you turn the wheel, both the flyer and the

bobbin go round as swiftly as before; but does the thread wind upon the bobbin?"

*C.* "No; it does not!"

*F.* "Besides, if the thread wound up as swiftly as the bobbin turns round, do you think your fingers could draw out the flax, and unite it into a thread, sufficiently fast?"

*C.* "Why, no; I cannot spin so fast as that; and so the thread would be for ever breaking, particularly when I stop a few moments, as I frequently must, when there are unevennesses in the flax, to correct the thread."

*F.* "You see, therefore, if this were the case, you must spin much more in an hour than you possibly can with all your diligence, and that the bobbin must be much sooner full."

*C.* "It appears so, indeed: but how is it, then, that the thread does wind round the bobbin?"

*F.* "That is the very question which you thought at first so simple. In the first place, the string that turns round the bobbin and flyer is double; one string passing over the pulley of the flyer, the other over the pulley of the bobbin. If you put both on the



pulley of the flyer, the thread will not be wound up. Farther, the bobbin, you know, is moveable round the axis of the flyer, and can turn independently of it. If both go round equally fast, the thread will not wind round the bobbin."

C. "I think now I understand something of it. The bobbin must turn round faster than the flyer, and this must be effected by means of the string passing round it. Am I right?"

F. "Perfectly: and you will readily conceive, that, if the bobbin turn round in the same direction as the flyer, but a little more swiftly, the thread, which passes through this staple of the flyer must wind round the bobbin."

C. "That I comprehend very well."

F. "To understand it the better, we will make a mark with chalk on the wheel, the bobbin, and the flyer. I will now turn the wheel round slowly once, and do you observe how often the flyer goes round in the mean while?"

C. "Six times."

F. "Now observe how often the bobbin goes round during one turn of the wheel."

C. "Seven times."

F. "Thus, then, as the bobbin makes one more turn than the flyer in every turn of the wheel, the thread must wind once round the bobbin every time the wheel goes round."

C. "True: now the whole is clear."

F. "The whole! let us see. What necessity is there, to make the flyer turn round so swiftly? The machine might have been so contrived, that the bobbin and wheel should go round together, and the thread wind round it in a similar manner; or the wheel might be turned round more slowly, and the thread suffered to wind up on the circumference of the wheel itself."

C. "But that would not be so convenient."

F. "Very likely. This, however, is not the only reason. Beside the convenience to the spinner, the bobbin is necessary for twisting the thread properly, and smoothing it's surface by friction."

C. "Still what is the reason, that the bobbin goes round oftener than the flyer, since they are both turned by the same wheel?"

*F.* "Your question shows, that you reflect on the subject. You will readily understand, that the flyer must move round six times, while the wheel moves round once, because the circumference of it's pulley, over which the string passes, is equal only to a sixth part of the circumference of the wheel. For, as the string is strained tight both upon the wheel and the pulley, when the wheel turns once round it carries with it as much of the string as is equal to the circumference of the wheel, or six times the circumference of the pulley, so that it must consequently turn the pulley round six times."

*C.* "I understand that clearly."

*F.* "Now, if you look at the pulley of the bobbin, over which the other string passes, you will perceive it is somewhat smaller: in your's it is equal to a seventh part of the circumference of the wheel, and consequently the bobbin goes round seven times while the wheel makes one turn."

*C.* "I did not think, that the turner had so much to consider and reflect upon, when he made a spinning-wheel."

*F.* "In fact he reflects very little. Turners make these useful implements, just

as other mechanics make their violins, harp-fichords, and indeed almost every thing, according to the rules they learned from their masters in their apprenticeship, and the measures they were once taught, without troubling themselves about the principles, on which they are constructed. Hence these are not always followed as they ought; and in many cases there is room for improving most implements, if their makers possessed more theoretical knowledge. The honour of reflection belongs almost exclusively to inventors and improvers. Thus we are indebted for the invention of the common spinning-wheel to a german, of the name of Juergens, who lived at Brunswic near three hundred years ago; and this ingenious machinery, that moves the bobbin backward and forward, without which it would be necessary to be frequently shifting the thread from one staple on the flyer to another, to the great interruption of the work, and danger of breaking the thread, was lately invented by Mr. Antis, of Fulneck, near Leeds, for which a premium was bestowed on him by the Society for the promotion of arts and commerce."



C. "I shall now be still fonder of my spinning-wheel, since you have taught me to understand it: but for this instruction, I might have continued spinning all my life, perhaps, without once thinking what I was actually about."

F. "One more question, however: as you are so diligent, how much can you spin in an hour?"

C. "My mother tells me, that I shall soon be able to spin about five skeins of thread."

F. "That is a hundred and fifty yards; for the reel is a yard in circumference, and each skein is thirty rounds of the reel."

C. "That is a great deal."

F. "Yet you would spin a great deal more, if the thread wound once round the bobbin every time you turned the wheel round. Let us suppose, that your foot depresses the treadle twice in a second, and that the circumference of the bobbin is only two inches, in this case four inches of thread would be wound upon it every second, and sixty times four, or 240 inches, in every minute. But 240 inches are twenty feet, which would be 1200 feet, or 400 yards in an hour."

C. "Then I shall not spin half so much as I ought to do, according to your calculation."

F. "Very true: and the reason is, no doubt, that an expert spinner cannot form the thread so fast as the bobbin goes round. She checks the thread, to alter places where it runs uneven, and the like; this does not occur at regular periods; and thus the bobbin runs sometimes slower than it does at other times, but always faster than the flyer. Hence you see how necessary it is, for the bobbin to have a separate motion of its own."

"You have now enough of the theory, to go on with your practice."

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## CHAP. XLIV.

### OF BEAMS AND PLANKS.

WILLIAM one day seeing a large beam conveying along the road on a timber-carriage, was surprised to observe, that it bent. "I did not think," said he, "that such a thick beam would bend."

“ Yet it is very natural,” answered his father: “ the thickest beam can bend as well as the slightest lath; it depends entirely on the proportion of the weight to the strength of the body. If you consider the thickness of the beam, you will find, that the weight of the part which lies behind the axletree cannot be small. How much do you suppose the weight may be, that acts upon the unsupported end?”

*William.* “ I do not know.”

*F.* “ Let us endeavour to estimate it: It is good to acquire an accuracy of eye in our youth, and indeed of touch and ear, which may be done by frequent practice. If we often compare unknown lengths, breadths, thicknesses, and heights, at different distances from the eye, with things of which we already know the dimensions, we shall soon be able to judge with tolerable accuracy the length, breadth, or height of a room, a building, or the like. So of weights; if we frequently take a known weight of one, two, or more ounces, or pounds, and remark the degree of exertion it requires to support it, which is commonly called poising it, we

shall soon acquire a readiness at estimating the weights of things."

*W.* "But we cannot apply this to very large bodies, such as this beam for instance."

*F.* "True: yet here we may call in the assistance of the eye. Thus I should suppose the end of the beam to project ten feet beyond the axle tree, and to be a foot broad, and a foot thick: consequently to contain ten cubic feet. Now oak is nearly of the same specific gravity with water, and I know, that a cubic foot of water weighs 62 pounds and a half. The weight therefore must be, if we reckon the cubic foot of oak two pounds and a half lighter than a cubic foot of water?

*W.* "Ten times 60 pounds, or 600 pounds in the whole. And this weight, from what you taught me some time ago on the subject of the lever, must be equally divided between the two ends, so that the unsupported end is depressed by a weight of 300 pounds."

*F.* "Very just: and this weight may readily be presumed sufficient, to overcome the cohesion of the particles of the wood in a



small degree, so as to occasion a perceptible bending in a length of ten feet.

“ It may not be amiss to observe to you on the present occasion, that the bending of a piece of timber frequently depends much on the position, in which it is placed. The beam before us is square, so that it matters not on which side it lies: but in a plank, which is much broader than it is thick, the case is very different. You have often seen a carpenter carrying planks upon his shoulder, and must have observed, that they bend a great deal when laid flat; on the contrary, if they be laid edgewise, their weight is not sufficient to bend them perceptibly in that direction, though then the motion of carrying them along will make them bend from side to side. Builders are well acquainted with this principle; and as it is of importance to them, to prevent, as much as possible, the timbers of a house from bending, I will some day go with you to a house that is building, and desire the carpenter to point out to you the ingenious methods, that have been devised for this purpose.”

## CHAP. XLV.

HOW TO WEIGH A BEAM WITHOUT A  
STEELYARD OR SCALES.

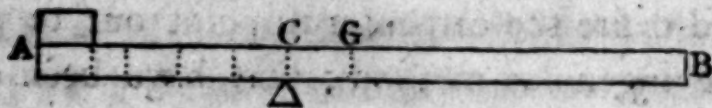
*Father.* "We just now estimated the weight of the beam, by guessing at it's contents in cubic feet, and multiplying these by the weight of one cubic foot of the timber: but could we not find the weight of the beam in some other way?"

*William.* "By a very large steelyard."

*F.* "True; we might do it in that manner without difficulty; and there are steelyards, in many places, large enough to weigh a loaded waggon. But is it not to be done without any such help?"

*W.* "I cannot tell how."

*F.* "There is no such great difficulty in it. Draw the following figure.



Let A B be the beam, and G it's centre of gravity. Now if the beam rested on a sup-

port at it's centre of gravity, the two ends would be in equilibrium, or balance each other. But if the support were on one side of the centre of gravity, as at C, the longer end, B, would sink to the ground. To restore it's equilibrium, a weight must be placed at A; and from the weight required, and it's distance, with that of the centre of gravity, from the point of support, the weight of the beam may be calculated. Perhaps you could make the calculation yourself, recollecting the law, that the powers will be in the inverse proportion of their distances from the point of support when they are in equilibrio."

*W.* "Since we may consider the weight of the beam as lying in the centre of gravity G, we may say, as C G is to C A, so is the weight A to the weight at G, or the whole weight of the beam."

*R.* "Suppose, then, that A C is five times the length of C G, and we are obliged to place exactly a hundred weight at A to produce an equilibrium, what will be the weight of the beam?"

*W.* "Five hundred weight."

*F.* "Hence we may deduce another mode of estimating the weight of a beam. Suppose I have attained by experience a knowledge of the exertion it requires for me to lift one, two, or three hundred weight from the ground. Now if the beam be lying on the earth, and I put a rope round one end, for the convenience of lifting it, taking it for granted, that the beam is not too heavy for this, could I not in this manner estimate the weight of the beam?"

*W.* "O yes: for as the end A rests on the ground, while the end B is raised, it is a lever of the second order, and as the beam is of the same size throughout, the power is as far again from the point of rest as the weight, so that the weight must be double the power."

*F.* "Accordingly, if the exertion I employ, to raise the end B, appear to me equal to what it would require to lift two hundred weight and a half, I may infer, that the beam must be about five hundred weight."



## CHAP. XLVI.

## HOW MEN STAND.

WHETHER a body be secure from falling, or not, depends upon the situation of it's centre of gravity.

In every standing body the centre of gravity must lie over some part of the surface upon which it stands, so that a line drawn perpendicular to the centre of gravity must fall within the limits of that surface. Thus, for example, a man cannot stand steady, unless a line let fall perpendicularly from between his hips, where his centre of gravity lies, touch the ground somewhere within the space of which his two feet form the boundary.

Hence it is obvious, that a quadruped, which has four feet, as a horse, must stand firmer than a biped, which has but two, as a man. A body may stand in an inclined posture, and yet steadily, if the perpendicular let fall from the centre of gravity be not without the limits of the surface on which it stands. A man may incline himself forwards,

backwards, or to either side, without falling, and without moving his feet; and the farther his feet are from each other in the direction in which he inclines himself, the greater this inclination may be.

Thus a man stands firmer when his feet are at a moderate distance from each other forwards and sideways at the same time, as in what dancing-masters call the fourth position, than when the feet are near together.

My young readers, no doubt, have already learned at the dancing-school, that they must turn out their toes, to stand gracefully. But turning out the toes in a moderate degree is not graceful merely, it is conducive to firmness of posture; for by this a man is rendered less liable to lose his equilibrium sideways, than if he turn his toes inwards, or place his feet parallel to each other, which is a faulty position according to the laws of mechanics, as well as the rules of dancing. Still, to turn the toes out too much is also faulty, and many dancing masters carry this too far. It is ungraceful; for what can be graceful, that is unnatural? Man's natural mode of walking is forwards; in doing which, however, he is to guard against falling on

either side. Accordingly nature has placed his feet in this direction, at the same time that she has given him muscles at the hips, which are capable of turning the whole leg, with the foot, somewhat outwards, and inwards also if it be necessary: but to turn them so far round, as to bring the heels as forward as the toes, cannot be done without a constrained action of the muscles, and a contorsion of the whole limb. A man walking forwards with his toes pointing directly to each side would appear a ridiculous figure to any one of uncorrupted taste; who had never seen such an exhibition before. This turning out of the toes too much is to be reprobated on account of it's insecurity also; for in consequence of it a man is liable to lose his equilibrium either backward or forward. The rules of dancing and mechanics should go hand in hand, otherwise the former must be defective: the latter never can, for they are the laws of nature.

The nearer the centre of gravity is to the surface that supports it, the less danger there is of it's being carried beyond this surface; and this is one reason why a man stands firmer with bent knees, as he does when he

expects any shock or thrust. But the chief advantage of this posture is, that a man can readily shift the situation of his centre of gravity, as the occasion may require; for which reason it is necessary, that he do not lower the centre of gravity so much, as to hinder the free action of his limbs. A man who should stand in a boat under sail, a carriage going along, or like one of Mr. Astley's pupils on a galloping horse, would act very imprudently, if he endeavoured to keep his legs straight, with a stiff knee. In some corporal exercises, where it is necessary to stand firm against external force, as in fencing and wrestling, the position with bended knees, which the rules of art prescribe, is founded therefore on solid principles.

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## CHAP. XLVII.

### AMUSING EXPERIMENTS RELATIVE TO THE CENTRE OF GRAVITY IN MEN.

Mr young readers may derive some amusement from the following experiments relative to the centre of gravity.



1. *To seat a person so, that he cannot rise up.*

Seat the person in a chair, so that his body shall be erect, his thighs in a horizontal position, and his legs perpendicular, and require him to rise up, without inclining his body forward, or his feet backward. Now, let him exert himself as much as he pleases, he will find it impracticable: for in this position his centre of gravity will be perpendicularly over his seat, and, if he would raise himself, the thighs act as two levers, bearing the weight of the body on their extremities at the hips, the knees form the fulcrum, and the moving power resides in the muscles, that extend the legs and thighs; but these, in such a position, act too obliquely, and their distance from the fulcrum is too little, for them to overcome the weight.

This is an experiment of considerable antiquity, for it is mentioned by Aristotle.

2. *To place a man so, that he cannot stand on one of his legs only.*

Place him with his side against a wall, so that the whole leg, on which he is to stand, shall touch the wall from the foot to the hip, and in this posture he will be unable, to raise

his other foot from the ground, since the moment he does so his centre of gravity will be unsupported, and he must fall.

3. *To place a person in a posture, in which he cannot take any thing from the ground just before his feet.*

Let him stand with his back against a wall, so that his heels shall touch it, and every attempt he makes to bend forward, to reach the object before his feet, he will be in danger of falling, as his centre of gravity is unsupported. It must be made a condition, however, that he shall not bend his knees. That he must not lay hold of any thing with his hand, to support himself, is a matter of course.

4. *At how great a distance can a man reach, to take up any thing from the ground?*

If a person stand freely on the open ground, with his feet close together, and his knees straight, he will not be able to take up a piece of money, or the like, that lies on the ground about two feet before him. With bended knees he can reach somewhat farther, without losing his equilibrium. To take up any thing, that is on one side of him, he must incline the lower part of the body a little.

backwards. If this be rendered impracticable, as by placing him with his back against a wall, as in the preceding instance, he cannot reach any thing sideways, even though close to his feet, without raising the opposite foot up into the air.

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## CHAP. XLVIII.

### SOME TOYS CONSTRUCTED ON THE PRINCIPLE OF THE CENTRE OF GRAVITY.

#### 1. *The posture master.*

Few of my readers, I presume, are unacquainted with the toy sold by this name. It is made of the pith of elder, with a bit of lead at the bottom. As the weight of the lead is considerable, compared with that of so light a substance as the pith of elder, the centre of gravity of the toy is in the leaden foot. Accordingly, if you incline the figure on one side, to the right for instance, the centre of gravity is unsupported it is true, yet it is not removed to the right hand beyond the point where the foot of the figure

still touches the ground, but remains still on the left hand; so that the foot will fall back into it's former position, and the figure re-assume it's erect posture, as soon as the force you employed to incline it is removed.

2. *A cylinder that rolls spontaneously up hill.*

Make a hollow cylinder of pasteboard, and fasten a narrow piece of lead on the inside in the direction of it's axis, or make a cylinder of light wood, and run a little melted lead into a hole near the circumference at one end, or at both. If such a cylinder be laid on an inclined plane, with the lead uppermost, but so as to be a little nearer the rising-side of the plane, as the lead, in which the centre of gravity of the cylinder lies, sinks downwards, the cylinder will ascend up the inclined plane, till the lead becomes lowermost, which may be when the cylinder has rolled up a space nearly equal to half it's circumference.

A clock, to point out the time of the day, has been constructed on this principle.

3. *A double cone which rolls (or rather appears to roll) up hill.*



A piece of wood is to be turned in the shape of two cones joined together at their bases. For this a stand is made, consisting of two pieces of wood, meeting at one end in an acute angle, and supported by three legs, in such a manner, that the angular point is lower than the opposite part of the stand. Thus the stand is an inclined plane, down which round bodies usually roll. But the double cone takes an opposite direction: for, if you place it at the angle of the stand, the sides are so close, that it must rest on the part where it is thickest; and consequently it's centre of gravity, which is in the middle of the axis, will be nearly half the thickness of the base above the support. On the other hand, though the sides of the stand are higher as their distance from the angle increases, they are more remote from each other, so that the cone can sink deeper between them, whence it's centre of gravity lies lower in fact at the upper end of the stand than at the lower end. Thus the cone rolls from the point of the angle toward the base, so that it appears to ascend up hill.

The less acute the angle of the stand, the faster the cone will roll: but there are three

circumstances, that affect it's motion: 1st, the angle of the stand; 2dly, the inclination which the plane of the stand makes with the horizon; 3dly, the angle which the sides of the cone make with it's axis. These three magnitudes should be in due proportion to each other. How this proportion is to be ascertained my readers will learn hereafter, if they pursue their mathematical studies.

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## CHAP. XLIX.

### OTHER TOYS OF A SIMILAR KIND.

#### 4. *The little sawyer.*

This well-known toy consists of a wooden figure of a man holding before him with both hands a frame-saw, which, near the lower end, passes through a piece of timber, glued fast to it at right angles. On that end of the timber, which passes behind the man, a leaden ball is fixed. If this figure be set on it's feet on the edge of a table, under which the timber passes freely, it will be preserved in equilibrio by the leaden ball; and if you give it's head a gentle push, it

will move backward and forward, as if sawing, and continue this motion some time. The leaden ball may be dispensed with, if the timber be made of sufficient length and weight.

The following is the principle, on which this toy is constructed. The centre of gravity of the whole figure, with the saw and leaden ball, lies under the feet of the puppet, so that it cannot fall, as long as those feet form the point of support; and when it is made to incline either way, the centre of gravity is raised and carried to one side of the perpendicular from the point of suspension, to which it must descend as a *pendulum* does, continuing to vibrate in a similar manner.

5. *The little rope-dancer.*

A puppet is made of wood, holding in it's hands, instead of a rope-dancer's pole, a semi-circular wire, the ends of which are turned downward, and reach below the feet of the puppet. Each end of the wire is loaded with a leaden ball, so that the centre of gravity falls under one of the feet of the figure, the other being carried backwards and raised in the air. This puppet will stand securely

on one foot on a thread stretched horizontally, and balance itself like a rope-dancer. If the thread be stretched obliquely, it will slide down, still preserving it's equilibrium.

6. *To hang a bottle of water on a little stick resting unconfined on the edge of a table.*

Round the neck of the bottle, or handle if it have one, tie a string sufficiently strong, with a loop of such a length, that the stick, when passed through it, and resting on the mouth of the bottle, shall form with the bottle an acute angle. If the stick be placed so as to be secure from slipping, when it rests upon the table, the greater part of the bottle will hang obliquely underneath it; and thus their common centre of gravity will lie underneath the point of suspension.

7. *The tumbler.*

This is a little puppet of wood, the body of which is made crooked in the shape of an S, hollow, and divided into two cavities by means of a transverse piece of wood, in which however there is a hole, to form a communication between the two. In one of these cavities is contained a little quicksilver, which can readily pass from one to the other through



the hole. The arms are moveable round an axis, which passes through the breast, and have a pulley at the shoulder, to which a silk thread is fastened, that passes under the clothes, and is made fast at the other end to the leg. Both the arms and legs must be made tolerably long, the better to balance the body.

If this figure be placed on the upper step of a stair made for it, so that the head lies lower than the belly, the quicksilver will run out of the cavity of the abdomen into that of the thorax, the head will incline downward, and the figure will stand on it's hands.

By this motion of the arms the silk thread is stretched, and draws over the legs, so that these, with the lower part of the body, acquire a preponderance, and the figure, turning over, arrives at the second step on it's feet. The quicksilver now runs out of the thorax into the abdomen, whence the belly, in consequence of the curvature of the figure, is thrown forward. The arms and upper part of the body then gain the preponderance, so that the figure turns over again; and in this manner it descends all the steps.

This ingenious toy must be made with great nicety, to succeed well. It is said to be a chinese invention: and though only a plaything for children, it's mechanism well deserves to be examined by my young readers, when they have an opportunity; as a mere description, which is all that can be given here, may not be sufficient to impart a complete idea of it.

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## CHAP. L.

### TWO MORE PROGNOSTICATORS OF WEATHER.

IN chapters xxv and xxvi animals have been mentioned, which prognosticate changes in the weather with tolerable certainty, and to these the two following may be added.

The thorny loach is one of these. The other species of the loach are very good eating, but this is tough and insipid. It is about a foot in length, as big as the manured reed, or large reed sometimes used for fishing-rods, and is slippery like an eel. This fish is kept in a large glass bottle full of water, with

two fingers depth of sand at the bottom. As long as the weather is settled, it remains quiet on the sand, and the water is clear; but if bad weather be coming on, it is restless, and winds itself about from place to place; after which rain, or wind, in general soon follows. If a heavy storm, or thunder, be approaching, it appears still more restless, and sometimes ascends to the top, as though it felt itself confined, and would creep out of the neck of the bottle, sometimes plunges into the sand, and wallows about in it, so as to render the water turbid, and itself invisible. This singular presension of a change in the weather it frequently displays four and twenty hours before it takes place.

To preserve this fish alive, the water must be changed frequently, and some crumbs of bread thrown into it.

Another prognosticator of weather is the leech, an animal found in ponds and ditches, and often of considerable utility to man,

This animal is very tenacious of life, so that, if it be cut in two, the parts thus separate will continue to move about in the water for several days, or even weeks. Here, however, let me intreat my young readers,

never to make experiments on any thing that has life, out of caprice, or premature curiosity. When physicians, or natural philosophers, inflict pain on animals, they do it, either to discover in them properties, that may be of utility to man, or to extend our knowledge of nature. And even this is not to be done wantonly: the end, that the philosopher proposes to himself, should be important; he should be careful, to make his experiments with all the tenderness possible, inflicting pain as little as may be; and he should never repeat them unnecessarily. No one of a feeling mind can reflect on the superfluous and reiterated barbarities of a Spallanzani, and some others, without horror. Unless for some important purpose, which children cannot have in view, the cruelty of mutilating or wounding a living creature, depriving it of the air necessary to it's existence, or even keeping it in confinement, is inexcusable. Though the mute animal cannot cry out for help, do not it's eager and convulsive movements tell you, that it feels pain, that it pants for life and liberty? Say not, to excuse your cruelty toward an irrational animal, that it has less sensibility, and



feels less pain than a man would feel. How know you the degree of pain, of which an animal is susceptible? Does not this very quality, of which we are talking, that of perceiving an approaching change in the weather, tend, with many others, to show, that the nerves of animals possess great sensibility?

To return from this digression, the leech, of which we were speaking, is frequently employed instead of the scarificator and cupping-glass by the physician. It is very greedy of blood, readily fixing on any animal, the skin of which is capable of being pierced by the instrument with which it is furnished for the purpose, and sucking it's blood, till it is completely distended with it. When a pond, or ditch, in which leeches are, is emptied, they frequently fasten on the naked legs of the labourers, from which they are not to be disengaged without violence, unless you sprinkle a little salt on them, which will make them drop off without risk of any injury to the part.

If you would employ the leech as an indicator of the weather, you must keep it in a glass vessel partly filled with water. In

serene settled weather it lies on the bottom, curled up like a snake. If rain be coming on, it ascends to the surface of the water, and remains there, till the weather begins to clear up. Against wind it swims about with great agility, and does not cease it's movements, till the wind begins to blow. When a thunderstorm is approaching, it remains some days out of the water, seems uneasy, and is convulsed. Throughout the winter it lies curled up at the bottom of the vessel, and takes it's winter sleep: but if it be about to snow, or thaw, it ascends to the mouth of the vessel. In general it remains at the bottom of the vessel in warm weather, at the top in cold.

Once a week in summer, and once a fortnight in winter, the leech should have fresh water, with some sand, and a little bran.

## CHAP. LI.

SOME EXPERIMENTS ON VIS INERTIÆ,  
AND THE COMMUNICATION OF MO-  
TION.

THERE is a moral, and there is a physical aversion to motion, or rather to a change of state. In some languages, from their general resemblance, they are called by one common name; though they are not so with us. The physical quality we call *inertia*, or *vis inertie*: the moral, from which I would hope my young readers are free, *sluggishness*, or *indolence*. The physical we all possess, however lively and active we may be. When from a state of rest we would set our bodies in motion, they require a certain degree of force, and a certain space of time, proportionate to the weight of our bodies, just as much as a stone or a log of wood would do. In like manner, when our bodies are once set in motion, time and force are requisite to bring them to a state of rest; so that, were it not for the kind attraction of our parent earth, we could not venture to take a leap

within doors, as we should dash our heads against the cieling; or in the open air, lest we should fly Heaven knows whither. This physical inertia, however, is a beneficial quality; and so is the moral, when it does not degenerate into abuse; but we must be careful, not to counteract it suddenly: it is with this, as with obstinacy; each yields to gentleness, while violence may be employed in vain.

When a boy is seated on a cart without a back, if they, who are to draw or push him along, set the vehicle in motion suddenly, the rider, unless he holds fast with his hands, inevitably falls backward. If there be a back to the cart, the back of the rider will strike against it. Why is this? The answer is, because the communication of motion requires time. The motion is communicated first to the part in contact with the seat, because of the friction between them, while the upper part of the body lags behind. Thus the centre of gravity is thrown behind the surface of support, and the body comes backward to the ground, with the legs commonly raised in the air, as these cannot so speedily change their position with respect to



the rest of the body, the occurrence being unexpected. If the friction against the seat be trifling, and the pull be very sudden, the seat will slip from under the rider, and he will come to the ground on his bottom.

If the motion be commenced slowly, and increased gradually, there will be time for it's communication, and the rider will retain his seat in safety.

When the motion is suddenly checked, the reverse takes place. As soon as a boat, that is sailing or rowing to land, touches the shore, every person in her is thrown forward. If a person in such a case be standing, his feet will be suddenly stopped with the boat, on account of the friction between them, while the motion of the upper part of the body will continue, so that he must fall, unless he advance one of his feet, or take the precaution to move his body backwards at the right time.

It is the same when a coach or other carriage is suddenly stopped, when a galloping horse stops short unexpectedly, and in other similar cases.

## CHAP. LII.

MORE CURIOUS EXPERIMENTS ON THE  
SAME SUBJECT.

THE house-maid, when the handle of her hair-broom is loose, reverses it, and strikes the end of the handle three or four times smartly against the ground. Why does she so? She has seen others do the same, and knows by experience, that it will fasten the handle, though she does not know the reason. The fact is, the quick motion of the handle is suddenly stopped, but the head of the broom, which is loose, continues in motion somewhat longer, and thus gets farther upon the handle, till it is stopped by it's tightness.

If you hold a sand-box in one hand, and strike upon it with the other, the sand will come out of the holes, because it cannot immediately acquire the quick motion downwards, which is given to the box by the stroke. The sand does not ascend, properly speaking, but the perforated top of the box is driven below the surface of the sand.

Lay a card upon a glass, a halfpenny upon the card, and with your fingers draw the card suddenly away, the halfpenny will fall into the glass. If you draw the card slowly, the halfpenny will be drawn off with the card; but when it is done quickly, the friction between the two being little, on account of the smoothness of the card, there is not time for the motion of the card to be communicated to the halfpenny, before it is drawn from under it.

The following experiments, founded on the communication of motion, excite considerable astonishment in those, who do not understand them.

Set a wine-glass on the table, or, if you would spare your glasses, split a card a little way, and set it upright, so that it may be thrown down easily. Suspend a tobacco-pipe in such a manner, that it's lower end may hang near the upper edge of the card. Now, if you strike the tobacco-pipe gently toward the card, it will remain whole, and the card will be thrown down: if you give it a smart stroke in this direction, the pipe will be broken, and the card remain erect. On the contrary, if you strike the pipe gently from the card, the pipe will remain

whole, and the card standing: if you strike it smartly in this direction, the pipe will be broken, and the card thrown down. This is not difficult to explain. When the stroke is smart, the motion cannot be communicated with sufficient quickness throughout the whole of the pipe, which, being brittle, breaks at the place where the stroke was given, each half turns round it's centre of gravity, and in consequence the lower end of the pipe, as well as the upper, will move in a direction contrary to the stroke.

Draw a hair through the stem of a tobacco-pipe, and fasten it horizontally at both ends, you may break the pipe stem in two by a smart stroke, without breaking the hair. The success of this experiment depends upon the skilfulness with which you make your stroke: this must be smart, and short, without letting the instrument, with which you strike, descend too low. The pipe breaks for the reason mentioned in the preceding paragraph; the hair remains whole on account of it's elasticity.

Hold a quarter of a sheet of paper between your finger and thumb, so that it may hang freely. If you push it, or strike gently against it, with a nail, the points of a pair



of compasses, or the like, it will give way and you cannot pierce it; but if you strike it smartly with either of these, you will make a hole through it.

You can easily shut an open door by pushing it, but if you give it a violent stroke with your fist, you will shake it only, not shut it. If you would shut a door with violence, you must take hold of it with your hand, and exert the power of the arm upon it by a motion gradually accelerated.

A moderate blow with a stick against a pane of glass will break it into several pieces; but a ball fired out of a musket will make a simple round hole in it; while the same ball, thrown with no great force, would break it to shivers.

To one arm of a balance suspend a weight by a long thread, and hang at the other arm a weight sufficient to counterpoise it. If, while you prevent the arm from rising by keeping your hand or finger on it, you raise the suspended weight a little way, and then let it fall, the thread will remain whole, and the other end of the beam will be raised. If you let the weight fall from a considerable height, the thread will snap, and the balance remain unmoved. If you suspend two weights

by a thread passing over a pulley, similar consequences will take place.

Pliny relates, that near the town of Harpasa, in Asia Minor, is a very large rock, which you can move with a single finger, while it obstinately resists a sturdy stroke. In this there is certainly nothing improbable, though it appears strange; for we may suppose the stone to rest on it's basis in the manner of a four-legged table, which has one leg too short; and this we know might be moved by the pressure of a finger, though a blow with a hammer would not stir it. The *logging-stones*, or *rocking-stones*, which still exist in different parts of our own island, are curious remains of antiquity of a similar kind, being stones of considerable bulk and weight, so nicely poised on a slender base, that a slight effort is sufficient to move them; though it would require a very great power to throw them down, from the shifting of their centre of gravity, in consequence of the change in the point on which they bear.

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### CHAP. LIII.

#### SUPPLEMENT TO THE FIRST CHAPTER.

WILLIAM wanted to pour back a glass of wine into the decanter, and set about it

very cautiously and slowly, that he might not spill any. The slower he poured, however, the worse he succeeded, the wine running down the side of the glass.

"Pour briskly," said his sister, who was a little older, and more experienced in such things, "or you will spill it all."

William took her advice, and was more successful.

"Do you perceive the reason of this?" said his father.

*William.* "Not very clearly. I rather feel it, than understand it."

*Father.* "So it is with many things in common life. Experience gives those, who do not trouble themselves about causes, a foreknowledge of effects to a certain degree. Every alehouse-keeper knows, that he must pour briskly out of his full mug, to fill the glass without spilling the liquor, though he is unacquainted with the theory of it. Every journeyman mason knows where he must lay hold of his crow to move a stone, though he is ignorant of the laws of the lever. The billiard-player can tell how he must strike his ball to hole his adversary's, though he has never studied the laws of percussion of elastic bodies. The waggoner



is able to judge, whether his horses be equal to the task of drawing a loaded waggon up a hill, though he has never heard of the theory of inclined planes. He must be very short-sighted, however, who hence concludes, that science is unnecessary.

“ The attraction that takes place between the particles of the liquor and the glass, and between the particles themselves, is the cause of the liquor’s running down the side of the glass. The first drop, which, were it acted upon by the power of gravitation alone, would fall perpendicularly from the brim of the glass, is detained by the attraction between the particles of the liquor, hangs a little over the brim of the glass, touches it’s external surface, is attracted by this, and slides down it, because it’s weight is too little to overcome this attraction. Each succeeding drop is drawn along by this, and in like manner runs down the side of the glass.”

W. “ How is it, then, that it runs down the side of the glass only at first, when the glass is pretty full, and goes into the decanter very well, when the glass is half empty ?”

F. “ When you pour out of a full glass, the side of the glass is inclined in a very acute



angle to the perpendicular, through which the drop would fall; of course it is very near to the drop, that is about to fall, and therefore it's attraction for it is considerable. When the glass is in part emptied, you must incline it more, to pour the liquor out, so that the side is carried farther from the drop, and consequently attracts it with less force."

*W.* "Now I understand it clearly, and perceive the reason, why pouring the liquor out briskly prevents it from running down the side. By doing this a quicker motion is given to the liquor, sufficient to overcome the attraction between it and the glass at first; and at the same time the glass is sooner brought to a greater inclination, and thus carried farther from the stream."

*F.* "You now know the reason why some vessels are made with a projecting brim all round, others with a projection at one part only, which we call a lip.

"Liquor may be prevented from running down the side of a vessel too, by smearing the outside, at the place where you intend to pour it out, with any thing, to which the liquor will not easily adhere, as grease, or the seed of clubmoss.

"Quicksilver will not trickle down the

side of a glass, because its particles have little attraction to the glass, more to each other, and considerable weight.

“If you would have a proof of the adhesion, that takes place between water and many other things, bring me a pair of scales, a bowl of water, and a trencher.”

William having brought these, the trencher was suspended horizontally beneath one of the scales, and balanced by putting weights into the other. The scales were then held in such a manner, that the bottom of the trencher just touched the surface of the water in the bowl, without sinking to it. The other scale then bore an ounce more, without raising the trencher; but on adding still more weight, the trencher was raised suddenly, so that it was evident, the water had held it down.

With one more experiment we shall conclude. Lay a bit of cork on the surface of some water in a wine-glass, and see whether it will stay in the middle. You will find, that it will always swim to the side of the glass, and the faster, the nearer it is to it. When it touches the side, it will be raised up a little likewise. Replace it in the middle as often as you will, it will still return to the side.

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END OF VOL. I.

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